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Review Article

Sleep Problems in Aging (Ageing) Adults: A Narrative Review

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Abstract

The recent literature on sleep problems in aging (ageing) adults has primarily focused on negative effects as well as risk factors, buffers, and interventions. The sleep problems have typically been self-reported or measured by actigraphy. The prevalence rates for sleep problems starting at age 60 have been variable, ranging from a low of 18% in the UK to a high of 50% in China, a variability that may relate to the type of sleep data and/or cross-cultural variation. Psychological effects have included dissatisfaction with life, unhealthy aging and affective/depressive mood states. Physical effects have included elevated blood pressure, impaired functionality, frailty, comorbidity and immune dysfunction. Cognitive impairment has also resulted from sleep problems, and aging brain biomarkers have included shorter telomere length, reduced gray matter volume and earlier mortality. Psychological risk factors have included meta-cognitive beliefs, worrying, loneliness, poor relationships and depression. Physical risk factors have included inactivity, napping and comorbidity. Buffers/protective factors have included retirement, light exercise, consumption of vegetables and melatonin as a sleep medication. Only a couple interventions could be found in this recent literature on sleep in aging adults including Cognitive Behavior Therapy and exercise. A few potential underlying mechanisms for disturbed sleep in aging adults include decreased vagal activity, increased connectivity in the brain making disconnecting for sleep difficult, inflammation and orexins. Although the data highlight the severity of sleep problems in the aging, they have been primarily based on self-report surveys that have yielded mixed results across samples.

Sleep Problems in Aging (Ageing) Adults: A Narrative Review

This narrative review involved entering the terms sleep and aging (ageing) into PubMed and PsycINFO. The search yielded 735 papers for the last five years. However, following exclusion criteria including case studies and non-English language papers, this review is a summary of the research reported in 67 papers. The recent literature is predominantly focused on negative effects of sleep problems along with studies on risk factors, buffers and interventions. This narrative review is accordingly divided into sections on prevalence of sleep problems in the aging, negative effects, risk factors, buffers and interventions. These are followed by sections on potential underlying mechanisms for sleep problems in the aging and methodological limitations of the research.

Sleep Measures

Sleep problems in the aging are typically based on the self-report scale called the Pittsburgh Sleep Quality Index (PSQI) [1]. The seven components of this index include sleep quality, latency, duration, efficiency, disturbances, sleep medications and daytime dysfunction. In this study, 78% reported good sleep quality. Other variables that are based on actigraphy or self-report include wake time after sleep onset, sleep efficiency and total sleep time. In this comparison of sleep assessments, these measures were correlated with the sleep disturbances component of the PSQI but not with the total PSQI score. Others have reported a positive correlation between actigraphy measures and self-report [2]. In their factor analysis, length of wakefulness during sleep, sleep duration and total sleep time were the factors measured. Self-report measures explained 61% of the variance in total sleep time assessed by actigraphy.

In a review on 15 of 133 publications on technology for monitoring sleep, more questionnaire studies were reported than smart phone or wearable technology research [3]. The authors suggested that continuous monitoring is more reliable than self-report measures. Night to night variability has been reported for sleep EEG, but when it has been averaged over 4 nights, there was decreased variability [4]. These authors concluded that wearable technology was superior to self-report data.

Prevalence of Sleep Problems in the Aging

Given the variability of the measures used in studying sleep problems, it is not surprising that there is variability in prevalence data across countries. The prevalence has ranged from 18% for low sleep efficiency in the UK [5] to more than 50% of people over 65 experiencing sleep problems in China [6]. In between those extremes the U.S. has reported more than 26% for waking in the night and 13% for waking too early [7].

The National Sleep Foundation has recommended 7-9 hours as the ideal sleep duration [8]. Both short sleep (less than 7 hours) and long sleep (greater than 9 hours) have been considered problematic. In several studies the negative effects of both short and long sleep have been referenced as an inverted U function.

The prevalence of long sleep has been increasingly reported as a problem in this literature on sleep problems in aging adults. In a study from China, 44% were reported to have poor sleep with 8% having short sleep less than five hours and 28% having long sleep greater than nine hours [9]. Another example is a study from Africa reporting that 14% were experiencing short sleep and 25% experiencing long sleep [10].

Long sleep propensity has been reported in another study as high napping and high maintenance in 20% of females and 30% of males based on actigraphy [11]. In the same study, adequate sleep was reported in 74% of women and 31% of men. And, inadequate sleep was noted in 6% of women and 30% of men. Inadequate sleep was correlated with mortality risk.

Negative Effects of Sleep Problems on Aging Adults

The recent literature on the negative effects of sleep problems on aging adults has addressed psychological effects including dissatisfaction with life, unhealthy aging and affective/ depressive mood states. Physical effects have included elevated blood pressure, reduced functionality, frailty, comorbidity and immune dysfunction. Cognitive impairment has also resulted from sleep problems, and aging brain effects have included shorter telomere length, reduced gray matter volume and earlier mortality.

Psychological Effects of Sleep Problems

Life satisfaction has been directly affected by sleep quality and indirectly affected by depressive symptoms, explaining respectively 84% and 16% of the variance in one study (Banerjee et al, 2022). Functional limitations exacerbated the indirect effect of poor sleep on life satisfaction in this research.

Healthy aging has also been affected by sleep quality which has been measured in different ways. For example, in a longitudinal study, sleep quality and duration were explored as determinants of healthy aging [12]. In that study, highs and lows were determined for sleep quality in a sample who were older than 65 (N= 1226) and the participants were assessed again later for healthy aging. Thirty-four per cent of the sample was high on sleep quality and high on healthy aging at the follow-up. Greater sleep quality in the high-high group was based on the Pittsburgh Sleep Quality Index. The low-high group comprised 19% of the sample. This group could have gone from low to high as a function of being participants in research that often has therapeutic effects. The low-low group Included 31% of the sample. Sleep duration was inversely associated with being in the high-high group, suggesting an inverted U-curve with both short and long sleep being associated with negative effects.

In another study sleep efficiency was assessed in 65-to-96-year-old adults (N=2468) [13]. Sleep efficiency or the ratio of total sleep time in bed was noted to plummet to 76% in adults greater than 80-years-old. This decrease was associated with greater frailty, poor health and early mortality. In still another study, normal sleep time was associated with greater physical activity and less sedentary behavior which resulted in less unhealthy aging [14]. In contrast, the short sleepers (less than six hours a night) engaged in less physical activity and more sedentary behavior and were later noted to have unhealthy aging.

Negative affect and depressive symptoms have also resulted from inadequate sleep in a study called "Good night-good day? Bidirectional links of daily sleep quality with negative affect and stress reactivity in old age" [15]. In this study, 61- 90-year-old adults (N=325) were assessed for their nighttime sleep and their daytime stress. The data suggested that the older adults could regulate the effects of low sleep quality or negative affect but they had more difficulty down-regulating daytime stress effects on sleep. This study highlights the bidirectionality of sleep and negative affect.

In research based on data from the Health and Aging in Africa Study (N= 3891 adults greater than 40 years), the prevalence of incident depressive symptoms was 26% and the prevalence of persistent depressive symptoms was 31% [10]. The prevalence of very short sleep was 4%, short sleep 10%, normal sleep 61% and long sleep 25%. In this sample, long sleep was associated with both incident depressive symptoms and persistent depressive symptoms but only for men not for women.

In still another sample experiencing depressive symptoms related to sleep disturbances, C-reactive protein (a marker of inflammation) that was assayed in 2012 mediated the effects of sleep disturbances on depressive symptoms that were assessed in 2017 [16]. However, these effects were only noted in women. These results suggested that inflammation mediated the relationship between sleep disturbances and depressive symptoms. The gender differences noted in these two studies are difficult to interpret.

Physical Effects of Sleep Problems

The physical effects of sleep problems in the aging have included abnormal blood pressure, hearing loss, disturbed functionality, frailty, falling and comorbidity. Although sleep deprivation studies have rarely been conducted recently, at least one appeared in this literature [17]. In that study (N= 20, mean

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age = 60), blood pressure increased for both males and females following 24 hours of sleep deprivation.

Hearing loss has been associated with sleep problems in the National Health and Nutrition Examination Survey [18]. In this sample (N=632 adults greater than 70-years-old), greater than 8 hours sleep led to poorer perception of high frequency pure tones. The direction of these effects cannot be determined given the cross-sectional nature of these data. However, hearing loss and sleep problems may be bi-directional.

Functional limitations have also been noted to follow from sleep problems in the National Health and Nutrition Examination Survey (N =6020 adults who were older than 65 years) [19]. In this study, those who had short sleep (less than five hours) as well as those with long sleep (greater than nine hours) had inferior performance on 19 functional tasks including basic activities of daily living such as dressing and eating. Other negative effects were noted for instrumental activities of daily living such as shopping and cooking, leisure and social activities, extremity mobility and general physical activity.

Frailty has also been negatively affected by sleep problems in aging adults in at least three studies in this recent literature including one already mentioned where sleep efficiency was associated with frailty (Desjardins et al, 2019). In another study, both short (11%) and long (18%) sleep groups had greater physical frailty (N = 9824, mean age= 74) [20]. Long sleep was a risk factor for frailty in still another study. In this sample (N = 1726 60- to 87-year-old adults), 44% had poor sleep quality including 8% who were experiencing less than five hours and 28% who were experiencing greater than nine hours. Ratings on frailty suggested that 9% were classified as frail and 53% as pre-frail. Poor sleep quality especially long sleep (greater than nine hours) led to greater odds of frailty.

Given the prevalence of frailty, and its relation to long sleep, it is perhaps not surprising that the risk of falling is also associated with long sleep. In this sample (N=902) 2.35 greater odds were noted for long sleep time (greater than 9 hours) contributing to falling.

Comorbidity is surprisingly mentioned in only one study in this recent literature on sleep problems in the aging. In this Canadian longitudinal sample, comorbidity was noted in as many as 30 to 70% of the participants (N= 30,011) Greater odds of comorbidity were noted in those reporting short sleep (less than six hours) or long sleep (greater than eight hours).

Immune function has also been affected by low sleep quality. For example, in a study that documented 15-month trajectories of sleep quality and interleukin-six (IL-6, another marker of inflammation), lower interleukin-six levels were noted in 84% of the sample and higher levels in 16% of the participants [21]. In this study (N= 195, mean age = 74), poor sleep quality led to higher IL-6 levels. Surprisingly, that was the only immune factor explored in this study.

Other immune factors associated with inflammation and immune dysfunction were studied in a sample from the Australian Research Council on Longevity [22]. In this research (N =230 63-to-70 year-old adults), difficulty falling asleep was associated with increased IL –2 and increased IL – 1 beta levels. The selection of specific immune factors has appeared to be arbitrary in these studies.

Cognitive Effects

Cognitive effects are the most frequently addressed in this recent literature (11 studies). In a sample from the World Health Organization Study on Global Aging and Adult Health, adults greater than 50 years of age who slept longer than nine hours on average had cognitive problems [23]. These problems were specified as attention, working memory and executive function. Long sleep has also been a problem for cognitive function in a sample from China [24]. In this sample (N= 9005, mean age =81), long sleep duration plus a greater than two hour increase in sleep time led to mild cognitive impairment.

In a study entitled "Long sleep duration associated with cognitive impairment in Chinese community -dwelling older adults" (N =1591 greater than 60 years), those who were sleeping more than nine hours experienced significant cognitive impairment [25]. On the Mini-mental State Exams, the older elderly (greater than 75-years-old) had low global cognition scores as well as reduced orientation memory, language ability and executive function scores.

Both long and short sleep have been associated with cognitive impairment. In the English Longitudinal Study of Aging, both baseline short and long sleep duration were associated with follow-up cognitive performance [26]. In this sample (N=4877), the inverted U function of both long and short sleep effects, surprisingly, only occurred for male participants which were difficult to interpret. The inverted U-shaped association between sleep duration and cognitive function has also been noted in the Social Isolation, Health and Lifestyle Survey in Singapore on a sample of adults greater than 60-years-old (N=4169) [27]. This association was less pronounced if the participants were married and were experiencing a strong social network.

In still another study, an inverted U-shaped association was noted between sleep problems and cognitive function. In this sample (N=1520 adults greater than 50-years-old), more than 10 hours of sleep was negatively associated with cognitive functions including fluency and delayed recall, and less than five hours sleep was associated with a greater error rate.

The inverted U function of sleep was again noted in the English Longitudinal Study of Ageing (N=28,756 older than 60-year-old adults) [28]. Impaired cognitive function was reported for those who slept less than four hours and those who slept more than 10 hours.

Two other specific cognitive functions that have been affected by sleep include visual paired associates and word learning [29]. In this sample (N=99 greater than 50-year-old adults), sleep was negatively correlated with those two memory variables. Visual paired associates was negatively correlated with the subjective sleep quality, duration and disturbance components of the Pittsburgh Sleep Quality Index. And word learning was negatively correlated with the subjective sleep quality and efficiency components of that scale.

Better sleep quality has been a mediator for the effects of physical activity on cognitive function [30]. In this sample from the European Longitudinal Study on Aging (N =86,541), better subjective sleep quality partially explained the association between self-reported physical activity and cognitive function. In this sample (N= 86,541) that was seen six times between 2004 and 2017, physical activity affected three cognitive functions including immediate recall, delayed recall and verbal fluency and these relationships were mediated by sleep quality.

Napping has also had negative effects on cognition. In a sample of adults greater than 60-years-old (N=1,740), greater than nine hours sleep at night and greater than 60 minutes napping led to cognitive impairment [31,32]. Similarly, less than seven hours of sleep and no napping had negative effects on cognition. Even worse effects for daytime sleep were noted in a study on brain morphological changes in the eighth decade of life. In this study (N= 457, mean age=76), an increase in weekend daytime sleep led to white matter loss in the brain.

These relationships between poor sleep and impaired cognitive function likely relate to measures of brain aging. Surprisingly, however, most of the former relationships were not measured in the same studies as brain age that tended to focus more on telomere length and diminishing gray and white matter volume based on neuroimaging data.

Brain Age Biomarkers

Telomere length (the DNA-protein structures at both ends of chromosomes protecting the chromosomes) has been an index of brain age associated with poor sleep quality.. In one study, long sleep duration, insomnia and insomnia associated with short objective sleep were independent factors associated with short telomere length [33]. These data suggested an inverted-U function with both long and short sleep being related to short telomere length.

Telomere length has also been called “a marker of cellular aging” [7]. In this sample (N=5268) from the U.S. Health and Retirement Study, 16% never felt rested, 26% had trouble waking up in the night and 13% were waking too early. Those who never felt rested in the morning had shorter telomere length. However, total sleep time was, surprisingly, not related to telomere length.

In an even longer longitudinal study from the Netherlands, sleep was assessed at baseline and telomere length was measured six years later [34]. In this sample (N=2936), delayed sleep onset was, once again, associated with shorter telomere length. And these authors referred to the shortening of telomere length as a “marker of biological age”.

Neuroimaging data have also been assessed for brain age [35]. In this sample (N =50) brain age delta (the difference between chronological age and brain age) was assessed using neuroimaging. The analysis revealed an association between inadequate sleep at baseline and brain age delta two years later.

A reduction in hippocampal volume has also been an indicator of brain aging [36]. In this sample (N = 417, mean age= 69), sleep duration, sleep problems and stress were associated with a reduction in hippocampal volume. A reduction in gray matter volume has also occurred in the right thalamus, the left precuneus and postcentral gyrus of aging adults following sleep restriction [37]. In a study entitled “Sleep and brain morphological changes in the eighth decade of life“, weekend daytime sleep increased. In this sample (N=457, mean age=76), an increase in weekday sleep and less efficient nighttime sleep were related to white matter loss. The direction of effects in this sample was difficult to determine given the cross-sectional nature of the study.

Early Mortality

Early mortality has been addressed as the most negative effect of sleep problems on aging adults. In a study on sleep and mortality (N=24,608 65-to-96-year-old adults), for example, sleep efficiency less than 80% was related to several factors including pain, nocturnal sleep, medication use, and awakening from bad dreams [13]. These sleep efficiency factors were not only associated with frailty and poor health but also with early mortality.

In a paper entitled “Sleep lengthening in late adulthood signals an increased risk of mortality”, longitudinal data were presented on baseline and follow-up sleep duration [38]. In this sample of 55-to-68-year-olds, long to long, short to short or short to long duration sleep increased the odds of all-cause mortality (caused by any disease but in this case mortality that related to cardiovascular conditions).

In a similar study entitled “Changes in nocturnal and daytime sleep durations predict all-cause mortality”, changes were explored in a sample from Singapore (N =2448 adults greater than 60 years) [39]. The results suggested that changes in either direction on nocturnal and nap duration led to early mortality.

In the Sleep Heart Health Study sample (N=4897), a brain age Index was created from calculating brain age minus chronological age (as in brain age delta already mentioned) based on sleep electroencephalography [40]. The data suggested that excess brain age was associated with decreased life expectancy.

In a unique study on centenarians, data were collected from 268 family members [41]. Sleep onset latency along with life satisfaction and attachment closeness were contributors to the number of days lived. These data were based on family member reports as opposed to self-reports, so they may be highly subjective and biased.

Risk Factors/Predictors of Sleep Problems in Aging Adults

Several risk factors have been identified for sleep problems in this recent literature on aging adults. Psychological risk factors have included meta-cognitive beliefs, worrying, loneliness, poor relationships and depression. Physical risk factors have included inactivity, napping and studies in which multiple risk factors have been identified.

Psychological Risk Factors/Predictors

In a study entitled "The influence of metacognitive beliefs on sleep dysfunction", actigraphy recordings were made of sleep across seven days in 50 participants [42]. These objective recordings were not associated with metacognitive activity. However, poor sleepers according to their self-reports had greater metacognitive beliefs about sleep difficulties.

The same research group in a later study entitled "Strategies for controlling sleep-related intrusive thoughts and subjective and objective sleep quality" identified different sleep problems by subjective and objective measures [43]. In this sample (N= 147), more time awake after sleep onset and less efficient sleep were noted on self-report. In contrast, longer sleep onset latency, less total sleep time and less sleep efficiency were revealed by actigraphy.

Loneliness has been identified as a risk factor for sleep problems in older adults in at least three studies. In a sample from the English Longitudinal Study on Ageing (N=5698), loneliness was associated with increased odds of reporting short sleep and long sleep problems at follow-up [44]. In another study, loneliness and isolation were compared (N= 759) [45]. Although a low correlation was noted between loneliness and isolation, both risk factors were associated with more disturbed sleep including waking after sleep onset and percentage sleep time based on 72 hours of actigraphy. Loneliness was associated with more insomnia and shorter sleep, and isolation was associated with more time in bed. This comparison is tentative inasmuch as only three items from the UCLA loneliness scale were used to assess loneliness whereas as many as nine items were used to assess isolation. Nonetheless, the comparison between effects of isolation and loneliness is unusual and the data are suggestive.

In a study entitled "Long time, no sleep", 29% of the sample (N= 71) reported increased sleep problems [46]. Loneliness as well as being a male were risk factors for greater sleep disturbances. In research that addressed the impact of retirement on sleep problems among older workers and their partners, two waves of the longitudinal study from the Netherlands were explored (N= 3726 older Dutch couples) [47]. Increased odds of sleep problems were associated with lower relationship quality and with having a partner who had sleep problems.

In a study entitled "Irregular sleep–wake patterns in older adults with current or remitted depression", the Sleep Regularity Index was used along with actigraphy (N=138) [48]. Sleep-wake fragmentation, sleep instability, sleep onset and offset timing and the number of awakenings were reportedly related to depression.

In another sample from the English Longitudinal Study on Ageing (N =5172 adults greater than 50-years-old) sleep was assessed via self-report and depression by the Center for Epidemiological Studies–Depression Scale [49]. Baseline depression and sleep problems predicted the same problems four years later.

Physical Risk Factors/Predictors

Inactivity, napping and comorbidity are among the physical risk factors/predictor variables in this recent literature on sleep problems in aging adults. In a study already reviewed, sleep-wake fragmentation occurred in older adults who were less active during the day [48].Those adults reported poor quality sleep and less regularity.

In a paper entitled "Analysis of dynamic, bidirectional associations in older adult physical activity and sleep quality", greater physical activity led to greater sleep on the same day [50]. And, surprisingly, long sleep one night led to short sleep the next night.

Napping, not surprisingly, has also been a risk factor for sleep problems in the aging. In a paper that gives its results in its title, "Napping characteristics and restricted participation in valued activities", data were sampled from the National Health and Aging Trends Study (N=1,739 greater than 65-year-old adults) [51]. In this study, each 30-minute increase in the duration of intentional or unintentional napping led to 25% decreased odds of engaging in any valued activity. This, of course, also included less physical activity.

Typically, more daytime sleep leads to less nighttime sleep. In a study entitled "Correlates and influences of taking an afternoon nap on nocturnal sleep ", more napping was associated with decreased sleep duration and increased light sleep as well as a delay of sleep onset at night [31,32]. In this study from China (N=50), the participants averaged 1-to-2 hour naps between 12 and 2 PM. The participants' reasons for napping were "belief in naps", "nothing to do", "low energy level", "compensating for disturbed sleep" and "extreme weather ".

Multiple risk factors have been reported in at least two studies. In one study that was focused on depression and poor sleep, several factors were associated with depression and sleep problems [49]. These included being a female, non-cohabitation, relative poverty, smoking, infrequent physical activity, frequent alcohol use, greater BMI, hypertension, coronary heart disease, diabetes/high glucose levels, pulmonary disease, arthritis and greater fibrinogen and C-reactive protein. Surprisingly, these risk factors were not submitted to a regression analysis or a structural equations analysis to determine their relative significance as predictors of sleep problems.

Similarly, multiple variables were identified in a longitudinal study [4]. In this sample (N=6375), latent class analysis was used to form sub-groups of sleep efficiency that was noted to decrease

19% between the ages of 40 and 100 years. The high efficiency group comprised 32% of the sample, the medium efficiency group included 50% of the sample and the low efficiency group comprised 18% of the sample. The high sleep efficiency group had a lower prevalence of previous hypertension, circulatory problems, general arthritis, breathing problems and recurrent episodes of depression.

The COVID-19 pandemic has also negatively affected sleep quality in at least two studies. For example, research from the U.S. reported a 29% increase in sleep problems of the aging related to the pandemic [46]. And, others have noted that sleep problems have been exacerbated by the pandemic [52]. These findings, however, were confounded by a significant decrease in activity and an increase in depression during the pandemic that were also related to the decrease in sleep quality.

Buffers / Protective Factors for Sleep Problems

Several buffers have been noted as protective of sleep in the aging. These have included retirement, light exercise, consumption of vegetables and melatonin as a sleep medication.

In the study on retirement, two waves of data were analyzed from the Netherlands longitudinal study on older Dutch couples (N=3726) [47]. In this study, retirement was followed by a decreased odds of sleep problems. This may have related to lower levels of work-related stress that no longer existed during retirement.

In a study entitled "Effects of sedentary behavior and activity on sleep quality in older people" sleep was monitored by actigraphy and physical activity by an accelerometer [53]. Replacing 30 minutes of sedentary activity with 30 minutes of light intensity exercise led to improved sleep quality. Surprisingly, vigorous intensity activity did not have the same effects.

In a study that explored the relationships between physical activity, sleep and cognitive function, sleep quality was a mediator between physical activity and cognitive function [54]. In this sample, physical activity attenuated the negative impact of poor sleep on cognition, again suggesting that physical activity had a buffering effect.

Plant-based diets have also had a buffering effect on sleep problems in aging adults. In a study entitled "Sleep duration, vegetable consumption and all–cause mortality among older adults in China", more vegetable consumption led to a 22% lower risk of mortality [55]. In this sample (N=13,441 greater than 65-year-old adults), less than five and greater than nine hours of sleep per night led to a greater mortality risk. Low vegetable consumption exacerbated the risk of mortality for the less than five and greater than nine hours of sleep groups.

Sleep has also been improved by melatonin. However, controlled substances for sleep including z-drugs like zolpidem (ambien) have been associated with falling and injuries [56].

Interventions for Sleep Problems in Aging Adults

Surprisingly, given the prevalence of sleep problems in aging adults, only a few intervention studies could be found in this recent literature. These include Cognitive Behavior Therapy and physical exercise. In a study on insomnia in older adults, sleep medication and medication for psychiatric disorders were noted to increase the risk of insomnia [57]. Cognitive Behavior Therapy including stimulus control, sleep restriction and sleep hygiene was more effective than medication. The positive effects of Cognitive Behavior Therapy were also noted in another study on insomnia [58].

Resistance exercise has reportedly improved all aspects of sleep, but especially sleep quality [59]. In this review of 13 studies, the consistent finding was that chronic resistance exercise protocols improved sleep quality. These data were not surprising given the already summarized research on daily activity as a buffer for sleep problems.

Potential Underlying Mechanisms for Sleep Problems in the Aging

A few potential underlying mechanisms have been suggested for disturbed sleep in aging adults. These include decreased vagal activity, increased connectivity (making disconnecting for sleep difficult), inflammation and orexins (neuropeptides that regulate sleep).

In a review paper on the balance of autonomic nervous system activity, exercise and sleep states in older adults, decreased vagal modulation was noted in several studies due to decreased parasympathetic activity during sleep [60]. Low levels of exercise confounded the effects of low vagal activity or likely contributed to the low vagal activity. As has been noted in research on exercise, the stimulation of pressure receptors under the skin by moving the skin (as in most exercise) increases vagal activity.

In a study entitled "Cerebral functional networks during sleep in young and older individuals", EEG and fMRIs were taken [61]. An increase in connectivity between the frontal regions of various networks during sleep was related to lighter sleep and fragmented sleep in these participants. The authors suggested that increased connectivity likely led to a lesser ability to disconnect during sleep.

In a sample from the Korean Brain Aging Study on 55-to-88 -year-olds (N=238), faster leukocyte telomere shortening was associated with shorter duration and longer latency sleep [62]. Inflammation was also suggested as a potential underlying mechanism for these sleep disturbances. Other mechanisms suggested by these researchers included oxidative stress, increased sympathetic tone and increased cortisol. Chronic inflammation was also related to insufficient sleep in the National Social Life, Health and Aging Project (N=1,124).

In a paper entitled "Physiological role of orexinergic system for health", orexins or hypocretins are defined as excitatory neuropeptides that regulate feeding, sleep and wakefulness, aging and neurodegenerative diseases [63]. These researchers also considered them a promising target for therapeutic approaches to obesity, drug addiction and emotional stress.

In another paper entitled "Sleep, orexins and cognition", orexins were said to regulate the sleep – wake cycle, reward and stress-processing, alertness, vigilance and cognitive function [64]. Alterations in central and peripheral orexins have been linked to narcolepsy, anorexia, age-related cognitive decline and neurodegenerative diseases. Orexin receptor antagonists can promote sleep signals during the night and orexin therapies can increase sleep and memory as well as cognition [65-67].

Methodological Limitations

Several methodological limitations can be noted about these recent studies on sleep problems in aging adults. Significant variability has been reported on the sampling methods, on the sample sizes, and the prevalence and results of the studies. Most of the research has involved self-report surveys which have been notably less reliable than continuous monitoring via actigraphy, although data from the two methods have been significantly correlated.

The key variables have been "pet variables" or those favored by the authors and often as single variables. And the data have frequently been analyzed via logistic regression analysis which controls for confounding variables. Some researchers have studied the controlled variables as risk factors or mediating/moderating variables and they have then been analyzed by mediation/ moderation or structural equations analysis.

More studies have appeared on negative effects versus risk factors for sleep problems. Several of the effects that have been noted could also be risk factors, as in bidirectional, reciprocal variables. Directionality cannot be determined as most of the studies are correlational and others that are longitudinal have instead analyzed cross-sectional data. Several of the scales are short, as in the Pittsburgh Sleep Quality Index , or biased as in the number of hours asleep which limits the reliability of these measures. The prevalence of sleep problems, its measures and its effects are sufficiently variable that reviews and meta-analyses have been inconclusive.

Many of the results are relationships between sleep problems and other effects, risk variables or protective factors selected by the researchers. The criteria for aging adults have been arbitrarily selected as being greater than 60 and the greater than 60-year-olds have rarely been compared to younger adults. Gender differences have been infrequently reported and when they have, researchers have expressed difficulty interpreting them.

Only a few potential underlying mechanisms have been studied, for example, decreased vagal activity and inflammation, but measures of potential mechanisms have not been compared. And, the intervention studies in this recent literature have been limited to Cognitive Behavior Therapy and physical exercise. Despite these methodological limitations, the recent literature highlights the relationships between sleep problems and aging, although aging hasn't been associated with more sleep problems necessarily than other stages of life.

Conclusions

Several studies on sleep problems in the aging have appeared in the literature over the last five years. They have typically been assessed by self-report or measured by actigraphy. The cut-off for aging has usually been 60 years of age and the prevalence has ranged from 18% to 50%. Several negative effects have been reported including dissatisfaction with life, unhealthy aging and affective/depressive mood states. More serious effects have included elevated blood pressure, impaired functionality, frailty, comorbidity and immune dysfunction. Cognitive impairment has been associated with aging brain biomarkers including shorter telomere length, reduced gray matter volume and earlier mortality. Risk factors/ predictors have included meta-cognitive beliefs, worrying, loneliness, poor relationships, depression, inactivity, napping and comorbidity. Buffers/protective factors have included retirement, light exercise, consumption of vegetables and melatonin and interventions include Cognitive Behavior Therapy and exercise. Decreased vagal activity, increased connectivity in the brain, inflammation and orexins have been addressed as potential underlying mechanisms for sleep problems in the aging. Despite the limitations of self-report surveys, the data have highlighted the severity of sleep problems for the aging and the need for further research.

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