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Original Article

Sleep and cognitive performance: cross-sectional associations in the UK Biobank

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ABSTRACT

Objective: The relationship between insomnia symptoms and cognitive performance is unclear, particularly at the population level. We conducted the largest examination of this association to date through analysis of the UK Biobank, a large population-based sample of adults aged 40–69 years. We also sought to determine associations between cognitive performance and self-reported chronotype, sleep medication use and sleep duration.

Methods: This cross-sectional, population-based study involved 477,529 participants, comprising 133,314 patients with frequent insomnia symptoms (age: 57.4 ± 7.7 years; 62.1% female) and 344,215 controls without insomnia symptoms (age: 56.1 ± 8.2 years; 52.0% female). Cognitive performance was assessed by a touchscreen test battery probing reasoning, basic reaction time, numeric memory, visual memory, and prospective memory. Adjusted models included relevant demographic, clinical, and sleep variables.

Results: Frequent insomnia symptoms were associated with cognitive impairment in unadjusted models; however, these effects were reversed after full adjustment, leaving those with frequent insomnia symptoms showing statistically better cognitive performance over those without. Relative to intermediate chronotype, evening chronotype was associated with superior task performance, while morning chronotype was associated with the poorest performance. Sleep medication use and both long (>9 h) and short (<7 h) sleep durations were associated with impaired performance.

Conclusions: Our results suggest that after adjustment for potential confounding variables, frequent insomnia symptoms may be associated with a small statistical advantage, which is unlikely to be clinically meaningful, on simple neurocognitive tasks. Further work is required to examine the mechanistic underpinnings of an apparent evening chronotype advantage in cognitive performance and the impairment associated with morning chronotype, sleep medication use, and sleep duration extremes.

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1. Introduction

Insomnia is defined as persistent difficulties with sleep initiation and/or maintenance, resulting in significant impairment to daytime functioning. At the symptom level, insomnia affects up to one-third of the adult population, while persistent insomnia affects approximately 10–12% and is associated with increased risk for cardiovascular disease, depression, and early mortality [1,2]. Both daytime functioning and quality of life are known to be severely affected in those with insomnia and often drive treatment seeking [3–5]. More specifically, previous work shows that the most commonly cited areas of daytime dysfunction are problems with fatigue, work performance, cognitive performance, and emotion regulation [6]. Insomnia has also been associated with a range of serious and non-serious sleep-related accidents [7].

While experimental sleep loss engenders reliable cognitive impairment, particularly for vigilance, complex attention, and working memory [8], there has been comparatively little work on insomnia. In general, the field has been characterised by mixed findings, with some studies showing impairment and others failing to observe differences from controls [9]. Nevertheless, meta-analytic data suggest that patients exhibit reliable impairments in tasks probing episodic memory, working memory, and problem solving, with small-to-medium effect sizes [10]. Recent, well-controlled studies have found evidence of insomnia-related impairments in switching of attention and working memory [11], and sustained attention and episodic memory [12]. However, there continues to be conflicting findings in the insomnia literature [13–15], and studies generally recruit small samples of patients with 'primary insomnia', who are otherwise healthy.

Larger epidemiology-based studies of insomnia symptoms and cognitive performance similarly display mixed results: showing evidence of impairment [16], no evidence of impairment [17] or impairment only for specific insomnia sub-groups [15,18]. To our knowledge, no study has investigated insomnia symptoms and cognitive performance in a large population-based sample of middle-aged adults, with a standardised test battery, while simultaneously appraising the effects of other important sleep variables, including chronotype, sleep duration, and sleep medication.

The present study aimed to conduct the largest investigation of insomnia symptoms and cognitive performance to date through analysis of UK Biobank data. The UK Biobank is a large population-based study of >500000 adults aged between 40 and 69 years, providing a unique opportunity to assess associations in groups of poor and good sleepers and to adequately control for the influence of several potential confounding variables. We hypothesised that insomnia would be independently associated with impairments in all measures of cognition (reasoning, basic reaction time, numeric memory, visual memory, and prospective memory) after controlling for potential confounding variables. As a secondary aim, we examined associations between cognitive performance and chronotype, sleep medication use and self-reported sleep duration.

2. Methods

2.1. Participants

Details of the UK Biobank are available elsewhere [19]. In brief, adults aged 40–69 years who were registered with the UK National Health Service and living within 25 miles of a study assessment centre were invited to participate. Approximately nine million invitations led to a final sample of 501,718 participants. For the purposes of the present study, participants were excluded if they self-reported a neurological condition (eg, neurodegenerative disease, stroke, head injury or epilepsy; n = 22,065), had a diagnosis of sleep-disordered breathing (n = 1511) or had incomplete data for insomnia symptoms (n = 613), leaving a total of 477,529 participants. Twenty-eight percent of the sample reported frequent insomnia symptoms (n = 133,314; mean age = 57.4 years, SD = 7.7 years; 62.1% female), while the remaining 72% of participants made up the comparison group (n = 344,215; mean age = 56.1 years, SD = 8.2 years; 52.0% female). This comparison group was composed of those reporting insomnia symptoms 'sometimes' [48%] and 'never/rarely' [28%].

2.2. Procedure and measurements

All the procedures performed in the UK Biobank research were approved by the NHS National Research Ethics Service (Ref. 11/NW/0382). All participants gave written informed consent. Assessments were conducted at 22 centres across England, Scotland, and Wales between 2006 and 2010. Questionnaires and cognitive assessments were administered in a standardised order using a computerised touchscreen interface, followed by a face-to-face interview with a research nurse to obtain additional data. Sleep-related variables and cognitive performance were assessed in a single visit that lasted approximately 90 min.

2.3. Sleep-related variables

To assess insomnia symptoms, participants were asked 'Do you have trouble falling asleep at night or do you wake up in the middle of the night?' with responses 'never/rarely', 'sometimes' and 'usually'. Participants were categorised as having frequent insomnia symptoms if they answered 'usually' to this question, while the remaining participants made up the control group without frequent insomnia symptoms. Chronotype was assessed using the following question: 'Do you consider yourself to be'…: 'definitely a "morning" person', 'more a "morning" than "evening" person', 'more an "evening" than "morning" person', 'definitely an "evening" person'. For the purposes of the present study, we collapsed the two middle responses into an 'intermediate' chronotype category, permitting comparisons with the 'definitely morning' and 'definitely evening' groups. Sleep duration was recorded as the number of reported hours to the following question: 'About how many hours sleep do you get in every 24 h? (include naps)'. Given previously established U-shape relationships with health and cognition [20], we categorised sleep duration into short (<7 h), normal (7–9 h) and long (>9 h) based on recent guidelines [21].

2.4. Cognitive performance

Five cognitive measures were administered through a computerised touchscreen interface [22]. Time to complete all five cognitive tests was approximately 15 min. The tests were designed specifically for the UK Biobank to allow administration at scale without examiner supervision. The tasks show evidence of an underlying performance factor and good stability over time, with the exception of visual memory performance, which has a comparatively lower intraclass correlation coefficient [22].