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Original Article

Short sleep duration and health outcomes: a systematic review, meta-analysis, and meta-regression

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ABSTRACT

Objective: The dose–response of short sleep duration in mortality has been studied, in addition to the incidences of notable health complications and diseases such as diabetes mellitus, hypertension, cardiovascular diseases, stroke, coronary heart diseases, obesity, depression, and dyslipidemia.
Methods: We collected data from prospective cohort studies with follow-ups of one year or more on associations between short sleep duration and the outcomes. For the independent variable, we divided participants at baseline into short sleepers and normal sleepers. The primary outcomes were defined as mortality and an incident of each health outcome in the long-term follow-up. Risk ratios (RRs) for each outcome were calculated through meta-analyses of adjusted data from individual studies. Sub-group and meta-regression analyses were performed to investigate the association between each outcome and the duration of short sleep.
Results: Data from a cumulative total of 5,172,710 participants were collected from 153 studies. Short sleep was significantly associated with the mortality outcome (RR, 1.12; 95% CI, 1.08–1.16). Similar significant results were observed in diabetes mellitus (1.37, 1.22–1.53), hypertension (1.17, 1.09–1.26), cardiovascular diseases (1.16, 1.10–1.23), coronary heart diseases (1.26, 1.15–1.38), and obesity (1.38, 1.25–1.53). There was no sufficient usable evidence for meta-analyses in depression and dyslipidemia. Meta-regression analyses found a linear association between a statistically significant increase in mortality and sleep duration at less than six hours. No dose–response was identified in the other outcomes.
Conclusions: Based on our findings, future studies should examine the effectiveness of psychosocial interventions to improve sleep on reducing these health outcomes in general community settings.

1. Introduction

Short sleepers are prevalent throughout the world. In the U.S., the age-adjusted mean sleep duration was 7.18 hours and the prevalence of sleepers reporting less than six hours of sleep was 29.2% in 2012 [1]. In several developed countries, the prevalence rate is not higher than in the U.S., but 11.3% in Canada and 9.8% in the U.K. [2].

Several systematic reviews have shown that short sleep duration is associated with important health outcomes including not only mortality [3–6] but also hypertension [5,7], cardiovascular diseases [8], stroke [9], diabetes mellitus [10,11], and obesity [12]. These have been regarded as phenotypes of metabolic abnormalities [13] or arteriosclerosis promotion [14,15] associated with short sleep duration. However, because these reviews investigated associations between short sleep duration and these health outcomes utilized various methodologies in conducting reviews, another systematic review may be needed where the same methodology is used across health outcomes. In this review, associations between short sleep and incidents of some important health outcomes, including dyslipidemia and depression, which have not yet been examined in previous reviews, should also be investigated. Although sleep duration less than six hours is reported to be

Abbreviations: CER, control event rate; CI, confidence interval; HR, hazard ratio; MOOSE, meta-analysis of observational studies in epidemiology; NOS, Newcastle–Ottawa scale; OR, odds ratio; PRISMA, preferred reporting items for systematic reviews and meta-analyses; RR, risk ratio.

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associated with higher risk than that of seven to eight hours (especially in terms of mortality outcome in previous cohort studies [16–19]), to the best of our knowledge, this has not been systematically examined in meta-analyses and meta-regression, which can contribute to publication bias and to let researchers speculate on mediator effects of sleep duration on health outcomes.

We therefore conducted a systematic review, meta-analyses, and meta-regression to examine if short sleep duration is associated with a higher prevalence of health outcomes using the same.

2. Methods

We performed the study in accordance with the PRISMA (preferred reporting items for systematic reviews and meta-analyses) [20] and the MOOSE (meta-analysis of observational studies in epidemiology) [21] guidelines, with these checklists (see Appendices S5 and S6 in the Supplementary material).

Two independent researchers (OI and MJ) separately assessed the eligibility, extracted data, and checked the quality of the included studies. Any disagreements were resolved through discussion between these two, and with a third reviewer (NW) if disagreements persisted.

2.1. Data sources and searches

The studies were initially identified on October 17, 2013, through a search of PubMed, PsycINFO, CINAHL, and Embase using pre-specified search terms (Appendices S1–S4). Major medical journals, conference proceedings, and reference lists of included studies and previous systematic reviews were also hand-searched for published, unpublished, and ongoing studies. To identify new studies published during the review process, we conducted a search of PubMed using the same search strategy on October 9, 2014 and on May 6, 2016.

2.2. Study selection

We included studies with a prospective cohort or randomized controlled trial design, conducted in community settings, which compared short with normal sleepers for mortality and incidence of health outcomes in a long-term follow-up. We limited studies to those with a minimum follow-up duration of one year from baseline, and a minimum of 20 participants. Studies were excluded if most participants were aged 20 years or younger at baseline, or if participants had been diagnosed with the health outcome at baseline. We also excluded studies that were conducted in inpatient settings and those that involved pharmacological interventions.

The eligibility of each study for inclusion was checked at two stages: (1) looking through the title and abstract and (2) checking the full text.

2.3. Data extraction and quality assessment

2.3.1. Definition of sleep duration

The definition of short sleep was based on the original paper because common sleep duration varies among cultures and ethnicities [22,23]. Durations of short sleep were incorporated into subgroup analyses and meta-regression as mediators (see below). When both a subjective (eg, sleep diary) and objective sleep duration (eg, actigraphy or polysomnography) were reported, we selected the former as the independent variable. Although a self-report survey may be unlikely to capture the actual amount of sleep per night in comparison with actigraphy [24] or polysomnography [25], objective measures may not always be utilized in general community settings and subjective measures might be preferable because of their applicability. When both sleep durations per day (possibly including a daytime nap) and per night were reported, we selected the latter.

The duration of normal sleep was also defined based on the original paper.

2.3.2. Outcome measures

The outcome was defined as mortality and incidence of health outcomes, which were diabetes mellitus, hypertension, dyslipidemia (hypo or hyperlipidemia), cardiovascular diseases (including events in the heart and brain), coronary heart diseases, stroke, obesity, and depression. When a formal diagnosis was not provided, a surrogate outcome (eg, coronary artery calcification instead of diagnosis of coronary artery diseases, a self-report of diabetes mellitus without evidence of formal diagnosis) was included in the primary analyses, but a sensitivity analysis was planned (see below).

2.3.3. Assessment of bias

We employed the Newcastle–Ottawa scale (NOS) [26] to assess the studies' quality. The instrument has three broad categories (patient selection, four criteria, comparability of study groups, one criterion, and assessment of the outcome, three criteria). For the comparability criteria, we allotted two stars according to the depth of statistical adjustment for risk factors in the original studies (eg, one star for age, sex, and race only, two stars for beyond these). Therefore, a study could reach a full mark with nine stars. For the second and third items of the outcome criteria, we defined, a priori, follow-up durations as reasonably long enough, and adequate follow-up of cohorts in terms of the percent lost to follow-up that was allowed for each disorder (ie, three years and 10% for any cause of mortality, two years and 20% for diabetes mellitus, two years and 20% hypertension, two years and 20% for dyslipidemia, three years and 10% for cardiovascular diseases, three years and 10% for coronary heart diseases, two years and 20% for obesity, and two years and 20% for depression, respectively).

Although previous meta-analyses [27,28] deemed quality of a study as high when it had five or more stars on the NOS criteria, we (a priori) set eight or more stars as high in order to focus on very high quality studies.

2.4. Data synthesis and analysis

We analyzed data y and conducted a meta-analysis for each dependent outcome. In the meta-analysis, we calculated risk ratios (RRs) by pooling adjusted RRs between short and normal sleep provided by the original studies with a random effects model. If hazard ratios (HRs) were reported in a study but RRs were not, the HRs were regarded as RRs. Among studies where odds ratios (ORs) were provided but not RRs, we calculated RRs by using the ORs and control event rates (CERs) in normal sleepers reported in the original studies. Regarding studies where both RRs and CERs were not reported, and only ORs were provided, CERs were borrowed from a study whose characteristics were similar. In the primary analyses, regarding studies where RRs were provided for subgroups separately (eg, male and female), data from these subgroups were combined using a fixed-effect meta-analysis.

Statistical heterogeneity between studies was investigated using the I^2 statistic [29], assuming an I^2 of 75% or greater to be an important level of inconsistency, as a previous review employed [30]. To assess publication bias, we used a funnel plot and Egger's test for all primary outcomes [31]. We used the "trim and fill" method to adjust the funnel plot and recalculated the results [32].

Although subgroup analyses should be interpreted with caution [33], we planned, a priori, to perform analyses for several types of baseline characteristics (ie, between 20 and 65 years of age, or aged 65 years or more; male or female).