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CLINICAL REVIEW

Sleep duration and risk of all-cause mortality: A flexible, non-linear, meta-regression of 40 prospective cohort studies

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SUMMARY

Approximately 27–37% of the general population experience prolonged sleep duration and 12–16% report shortened sleep duration. However, prolonged or shortened sleep duration may be associated with serious health problems.

A comprehensive, flexible, non-linear meta-regression with restricted cubic spline (RCS) was used to investigate the dose–response relationship between sleep duration and all-cause mortality in adults.

Medline (Ovid), Embase, EBSCOhost—PsycINFO, and EBSCOhost—CINAHL Plus databases, reference lists of relevant review articles, and included studies were searched up to Nov. 29, 2015. Prospective cohort studies investigating the association between sleep duration and all-cause mortality in adults with at least three categories of sleep duration were eligible for inclusion.

We eventually included in our study 40 cohort studies enrolling 2,200,425 participants with 271,507 deaths. A J-shaped association between sleep duration and all-cause mortality was present: compared with 7 h of sleep (reference for 24-h sleep duration), both shortened and prolonged sleep durations were associated with increased risk of all-cause mortality (4 h: relative risk [RR] = 1.05; 95% confidence interval [CI] = 1.02–1.07; 5 h: RR = 1.06; 95% CI = 1.03–1.09; 6 h: RR = 1.04; 95% CI = 1.03–1.06; 8 h: RR = 1.03; 95% CI = 1.02–1.05; 9 h: RR = 1.13; 95% CI = 1.10–1.16; 10 h: RR = 1.25; 95% CI = 1.22–1.28; 11 h: RR = 1.38; 95% CI = 1.33–1.44; $n = 29$; $P < 0.01$ for non-linear test). With regard to the night-sleep duration, prolonged night-sleep duration was associated with increased all-cause mortality (8 h: RR = 1.01; 95% CI = 0.99–1.02; 9 h: RR = 1.08; 95% CI = 1.05–1.11; 10 h: RR = 1.24; 95% CI = 1.21–1.28; $n = 13$; $P < 0.01$ for non-linear test). Subgroup analysis showed females with short sleep duration a day (<7 h) were at high risk of all-cause mortality (4 h: RR = 1.07; 95% CI = 1.02–1.13; 5 h: RR = 1.08; 95% CI = 1.03–1.14; 6 h: RR = 1.05; 95% CI = 1.02–1.09), but males were not (4 h: RR = 1.01; 95% CI = 0.96–1.06; 5 h: RR = 1.02; 95% CI = 0.97–1.08; 6 h: RR = 1.02; 95% CI = 0.98–1.06).

Abbreviations: BMI, body mass index; CIs, confidence intervals; HRs, hazard ratios; MOOSE, meta-analysis of observational studies in epidemiology; NOS, Newcastle–Ottawa Scale; RRs, relative risks; RCS, restricted cubic spline.

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The current evidence suggests that insufficient or prolonged sleep may increase all-cause mortality. Women may be more susceptible to short sleep duration on all-cause mortality.

Introduction

The health benefits of appropriate sleep duration are well established [1–3]. The optimal physical condition is often achieved with 7–8 h of daily sleep duration [4]. Studies have shown that a sleep duration shorter or longer than 7–8 h is associated with increased risk of chronic diseases, such as diabetes [5] and cardiovascular disease [6].

Sleep disturbances and suboptimal sleep quality are problems common to the elderly population [7]. In 2003, the National Sleep Foundation reported that approximately 27–37% of the study population experienced prolonged sleep duration and 12–16% reported shortened sleep duration [7]. Previous studies have focused on the effects of short sleep duration, given the significant impact of sleep deprivation on the public health in the society, which may result in substantial loss of productivity and health [4]. However, those who have prolonged sleep patterns may also be susceptible to other undesirable health conditions, such as depression [8]. Hypothetically, long sleep duration may considerably be associated with all-cause mortality. Maintaining a healthy sleep duration has become an important public health issue, and exploring the impact of shortened or prolonged sleep duration on potential health consequences represents a critical step to achieve improved public health.

A number of primary studies have demonstrated the association of shortened or prolonged sleep and increased risk of all-cause mortality [9–11]. Several narrative reviews exploring this topic were also published in the past two decades; none presented quantitative findings [1,4,12,17]. Two well-designed systematic review and meta-analyses [18,19], based on a category model, reported that both short and long sleep durations were significant predictors of death, compared with moderate duration; these studies provide valuable and considerable information to us. However, it is arguable that a categorical model in meta-analyses may introduce bias because of the implausible assumption of homogeneity of risk within categories [20]—the definition regarding "short" and "long" sleep varied across the studies. Another problem of category models is the risk of losing power and precision by dividing the exposure (and sample size) into several groups [20]. In addition, several cohort studies published recently were not included by them.

To offer clear and meaningful assessment of the association between sleep duration and all-cause mortality, we conducted, in light of the recently emerging studies, an updated meta-analysis of cohort studies. We used a flexible (multiple knots, for fitting non-linear trend) meta-regression approach, a more plausible statistical model (which treats sleep duration as a continuous variable rather than a categorical one), to analyze the association.

Glossary of terms

Restricted cubic spline	A smoothly joined piecewise polynomial with third-order polynomials fitted within each piecewise, which the left and (or) right tail of the curve are (is) restricted to linear. The joints of polynomials refer to knots. This function is usually used to fit the non-linear relationship.

Methods

Our meta-analysis was conducted according to the meta-analysis of observational studies in epidemiology (MOOSE) checklist [21].

Study identification

We included prospective cohort studies investigating the association of sleep duration and all-cause mortality in general adult populations with follow-up duration of 2 y or longer. To develop a flexible, non-linear meta-regression model, we required that an eligible study should have categorized sleep duration into three or more levels. If multiple publications were available for a study, we included the report with longest follow-up.

We searched Medline (Ovid), Embase, EBSCOhost—PsycINFO, and EBSCOhost—CINAHL Plus databases up to November 29, 2015 using the following search terms: "sleep deviation", "sleep disorders", "sleep duration", "night sleep", "nap", "sleep pattern", "sleepiness", "mortality", and "death" (Table S1, Appendix A). We set no limitations to publication language. We also screened the reference lists (Table S1, Appendix A) of relevant review articles [1,4,12,17–19] and included studies for additional information. Publications in languages other than English (such as Chinese, French, Japanese, German) were translated by our language advisor (Meng XY) who is proficient in Multilanguage. Conference abstracts, other published abstracts, and gray literature were not included in this meta-analysis.

Data collection

Two reviewers extracted the following data using a pre-defined, standardized data extraction form: name of first author, publication year, data collection method (e.g., self-reported or assessment tools), mean age at entry, follow-up period, sleep duration, subsets (e.g., male, female), quantitative serving size in each category, effect size (e.g., relative risks [RRs], hazard ratios [HRs]) with confidence intervals [CIs], and adjusted variables. If studies failed to report such information, the corresponding author(s) were contacted for the data. For each cohort, when different models of adjustments for results were presented, we extracted the one that adjusted for the largest number of confounders. The two reviewers resolved disagreements through discussion. We used "hours" as the common scale of sleep duration.

Two reviewers assessed the risk of bias of included studies using the Newcastle–Ottawa scale (NOS, Table S2, Appendix A) [22]. The NOS tool contains nine items, each item being assigned with a star if a study meets the criteria of the item. We defined a study to be of high risk of bias (i.e., low quality) if it received four stars or fewer and a low risk of bias (i.e., high-quality) with 7 stars or more [23,24]. The two reviewers resolved the