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CLINICAL REVIEW

Sleep and self-control: A systematic review and meta-analysis

Cristiano L. Guarana [a, *], Ji W. Ryu [a], Ernest H. O'Boyle Jr. [a, 1], Jaewook Lee [a], Christopher M. Barnes [b]

[a] Kelley School of Business, Indiana University, USA
[b] Foster School of Business, University of Washington, USA

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S U M M A R Y

Controlling impulses and overcoming temptations (i.e., self-control) are key aspects of living a productive life. There is a growing yet disperse literature indicating that sleep is an important predictor of self-control. The goal of this meta-analysis is to empirically integrate the findings from multiple literatures, and investigate whether sleep quality, and sleep duration predict self-control. To provide a thorough understanding of the proposed relationships, this meta-analysis also investigated potential differences between the level of analysis (between-individual vs. within-individual), research design (experiment vs. correlation; and cross-sectional vs. time-lagged), and types of measure (subjective vs. objective for sleep and self-control). A systematic review was conducted through ABI/Inform (including PsycInfo), ERIC, ProQuest Dissertation & Theses, PubMed, and Psychology Database using keywords related to self-control and sleep. Sixty-one independent studies met the inclusion criteria. The results, in general, suggest that sleep quality (between-individual 0.26, CI 0.21; 0.31; and within-individual 0.35, CI 0.24; 0.45), and sleep duration (between-individual 0.14, CI 0.07; 0.21; and within-individual 0.20, CI 0.09; 0.31) are all related to self-control. Given the impact of self-control on how individuals live productive lives, a future research agenda should include a deeper investigation in the causal process (potentially via prefrontal cortex activity) linking sleep and self-control, and an examination of the moderators (individual and contextual variables) that could impact the relationship between sleep and self-control.

Introduction

In everyday life, people encounter multiple situations that require controlling impulses and overcoming temptations. Take, for example, a visit to a favorite restaurant or bar. It takes some willpower to avoid overeating or overdrinking. This ability to effortfully inhibit impulses or overcoming temptations is called self-control [1], and everyday activities often require a considerable amount of self-control [2–4]. Yet, despite the need for self-control, people often do not exercise such self-control.

Low self-control has been directly or indirectly related to obesity, drug use, violent crime, personal debt, gambling, unplanned pregnancy, eating disorders, sexually transmitted disease, deviance, counter-productive work behavior, abusive supervision, unethical behavior, and procrastination [5,6]. Conversely, exerting self-control leads to success at school, superior physical and mental health, better ability to cope with problems, higher levels of job engagement, and work citizenship behaviors [5,6]. The importance of self-control for well-being and career success over a lifetime [7] has brought the attention of scholars from a variety of disciplines ranging from health psychology to business. Given the importance of self-control, an essential question has become what factors can enhance or undermine self-control.

A growing literature indicates that sleep is a potentially important antecedent of self-control [8]. Controlling impulses and overcoming temptations involves utilizing the prefrontal cortex, which is disproportionally affected by low sleep duration or quality [9,10]. Images from functional magnetic resonance (fMRI) have shown changes in the functional connectivity of the brain resulting in cognitive vulnerability when individuals are sleep deprived [11]. Indeed, sleep-deprived individuals have less brain activity in the prefrontal cortex, which is responsible for attention, impulse control,

* Corresponding author. Department of Management & Entrepreneurship, 1309 E. 10th St., Bloomington, IN 47405-1701, USA.
E-mail address: cguarana@iu.edu (C.L. Guarana).
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affect regulation, and decision-making processes [12–14]; characteristics that are presented when individuals exert self-control in a variety of domains [15].[2]

Some of the research on self-control has taken a trait-based perspective, highlighting how people who sleep less (or worse) in general tend to have less self-control [16,17]. Some have taken a state-based perspective, highlighting how the same person will exert more (or less) self-control on different days based in part on sleep from the night before [18,19]. Some of this research has examined sleep quality and some has examined sleep duration. We define sleep quality as having trouble in falling asleep, staying asleep, and the number of awakenings experienced when asleep; sleep duration as the amount of time an individual spends sleeping at night [20,21].

The studies in the sleep and self-control literature have utilized a wide variety of research designs, measures of sleep and self-control, and sample sizes. Perhaps most problematically for the sake of knowledge consolidation, this research has been scattered across many distinct literatures, including psychology, physiology, neuroscience, and management. Thus, although there is reason to believe that sleep is potentially an important antecedent of self-control, the lack of integration across this literature limits the degree to which the relationship between sleep and self-control can play a meaningful role in our understanding of these phenomena.

Accordingly, we engage in a broad empirical integration by conducting a meta-analysis of the relationship between sleep and self-control. This includes sleep quality and sleep duration as especially relevant characteristics of sleep, which have also been investigated sufficiently to be included in a meta-analysis. Moreover, we separate the between-person effects from the within-person effects. In between-person effects, researchers randomly assign participants to one of two conditions (sleep deprivation or control), and measure potential differences in self-control across conditions. In within-person effects, researchers assign the same individual to both conditions (sleep deprivation and control), and measure potential differences in self-control within each individual. As such, in within-person effects, the individual is his/her control group, making the design more conservative, and the results more robust. In conducting separate analyses between- and within-individuals we minimize concerns related to aggregation bias, and ecological fallacy. We also separated studies that adopted different research designs (experiment vs. correlation; and cross-sectional vs. time-lagged) to better understand the pattern and strength of the relationships between sleep and self-control. In addition, we conducted analyses based on different measures of sleep and self-control (subjective vs. objective) to understand if measurement types affected the proposed relationships. Finally, we examine the incremental effects of each sleep characteristic above and beyond the other, which helps to quantitatively clarify the degree to which each sleep characteristic has non-redundant effects. The resulting meta-analysis clarifies the quantitative nature of the foundationally important relationship between sleep and self-control, which has important implications for everyday behaviors.

Methods

In accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement, we took the following steps: a systematic literature search, screening studies based on inclusion criteria, extraction of relevant data from the selected studies, aggregating the data, and reporting the results.

Search strategy

The systematic literature search was conducted on the databases ABI/Inform (including PsycInfo), ERIC, PubMed, ProQuest Dissertation & Theses, and Psychology Database. Using the Boolean search method, we searched for keywords related to sleep (i.e., sleep*, nap*) paired with keywords related to self-control (e.g., self-control, impulsive*, impulse control, willpower, self-regulation, self-discipline). In doing so, we excluded the keyword insomnia and applied limiters of document type (e.g., Dissertations & Theses, Scholarly Journals). The search period we adopted for this meta-analysis ended in March 2021, with the earliest study being published in 1874. Appendix A provides full information on the search strategy.

Study selection

Among the identified studies, we selected the studies which satisfied the following inclusion criteria:

Study type

Primary studies published in English were included if they reported a relationship between sleep and self-control. Other types of studies, including reviews, meta-analyses, generic presentations, case reports, comments, and books were excluded. Studies that are not accessible online or which used the same data already analyzed in other studies were also excluded.

Participants

Participants from all age ranges were included. Participants who reported any clinical diagnosis, substance use/abuse issues, pregnancy, or traumatic life experience (e.g., veterans with combat experience) were excluded to minimize the presence of potential confounding variables that would limit the interpretation of the findings. Children whose parents were incarcerated or had alcohol abuse were also excluded.

Sleep

Measures of sleep quality, sleep duration, and nap were included. Please see Appendix B for a comprehensive list of the sleep measures included in this study. Sleep disorders (e.g., insomnia disorder, sleep-disordered breathing, parasomnia, and dyssomnia) and sleep-related measures that did not directly represent duration or quality (e.g., sleepiness, snoring, sleep hygiene, and sleep habits) were excluded.

Self-control

Subjective (e.g., self-reported) or objective measures of self-control were included. Self-control has been studied across various fields of studies, which led to a wide variety of measures with different traditions (Duckworth & Kern, 2011). In their systematic review of self-control, Duckworth and Kern (2011) categorized self-control measures into three groups – executive function tasks (e.g., Stroop task), delay of gratification tasks (e.g., Gift wrap task), and self- and informant-report personality questionnaires (e.g., BIS-11, Parent child behavior checklist scores)– and found moderate convergence across these measures, which supports their construct validity as measures of self-control. Thus, we included all three types of self-control in our study. Please see Appendix B for a comprehensive list of the self-control measures included in this study. ADHD symptoms and general regulatory behaviors in daily

[2] We acknowledge that other factors related to the frontoparietal executive control network could also influence the relationship between sleep and self-control. However, this literature is still in its infancy, and to keep our logic concise we emphasized the role of the pre-frontal cortex. We expand this discussion later in the manuscript.

life (e.g., smoking) were excluded to avoid the introduction of systematic noise and the potential presence of confounding variables.

Time scale of measures

Sleep and self-control should be matched in their time scale (i.e., state sleep – state self-control; trait-like sleep – trait-like self-control). We considered sleep measures with a time window equal to or shorter than a month as state sleep[3] and those with a time window longer than a month as trait-like sleep. When the relationship between state sleep and state self-control was reported, only studies that measured state sleep before state self-control or measured them simultaneously were eligible.

Data extraction

We manually extracted the following information from all selected studies: title, authors, publication year, publication type (i.e., published vs. not published), the mean age of participants, the proportion of female participants, study designs (i.e., experiment vs. correlation; cross-sectional vs. time-lagged), level of analyses (i.e., between-individual vs. within-individual), the number of participants, variable names, category of sleep variable (i.e., quality vs. duration), types of measures (i.e., subjective vs. objective measure of sleep and self-control), correlations between sleep and self-control, and correlations between different categories of sleep variables. If needed, we coded sample size, mean, and SD of sleep-deprived (or poor sleep quality) group and control groups, which were transformed into correlation by using a web-based effect-size calculator (https://campbellcollaboration.org/escalc/html/EffectSizeCalculator-Home.php). The first and second authors independently coded a subsample of studies (k = 10) and assessed all differences. Once this alignment session was complete, we pulled another subsample of studies (k = 6) and found very high inter-rater reliability (IRR = 0.99) for both quantitative and qualitative information. Then, the first author coded the rest of the studies, which the second author reviewed to reduce potential human error. Any disagreements were discussed until agreement was reached on all of the coding decisions.

Bias assessment

Each included study was evaluated for risk of bias using the Joanna Briggs Institute (JBI) checklist. For correlational studies, we used JBI Critical Appraisal Checklist for Analytical Cross Sectional Studies (see Appendix C). For experimental studies, JBI Critical Appraisal Checklist for Randomized Controlled Trials (see Appendix D).

Meta-analytic calculations

We used Lipsey and Wilson [22] equations for both the bivariate correlations and meta-regressions in the R program, *metafor* [23]. Specifically, we used restricted maximum likelihood as recommended by Viechtbauer [24] for both sets of analyses, and the Knapp and Hartung [25] adjustment was included for the meta-regressions. We report the weighted mean correlation ($\bar{r}$), 95% confidence interval (CI), 2-sided p-value (p), standard error (SE), between-study variance (τ^2), 80% prediction interval, Q-statistic, and I^2. Wide prediction intervals, significant Q-statistics, and high (>0.50) I^2 statistics indicate substantial heterogeneity due to possible moderators. Moderator analyses were limited to instances where there were at least three (3) studies. We checked for publication bias using Duval and Tweedie's [26] trim-and-fill test.

To determine the individual and joint contributions of sleep quality and sleep duration in explaining self-control, we used matrix regression and relative weights analysis (RWA) in SPSS 26.0 with syntax provided in Johnson and LeBreton [27–29]. RWA overcomes ordinal information about magnitude by determining the absolute contribution of each predictor to the overall amount of explained variance (raw weight) as well as what percentage of the explained variance is attributable to each predictor (relative weight).

Results

We initially identified 1634 potential data sources. After excluding duplicates and articles that did not meet inclusion criteria, we included the 57 articles (62 independent studies) contributing 100 unique effects for systematic review and meta-analysis presented in Table 1. In addition to screening out non-relevant studies, we also screened for effect size outliers. Of the 100 effect sizes, two were found to be significant outliers (more than three standard deviations above or below the mean estimate). Substantive results were largely unaffected by their inclusion, but the removal of the two outliers did reduce some of the effect size heterogeneity for those two analyses. As one of the two outliers was the only effect size from the study, we had 56 articles (61 independent studies) as the final set of our data (see Fig. 1—Prisma). In total, 54,670 participants were included across the six (6) bivariate analyses with sample sizes ranging from 738 (sleep quality and sleep duration) to 42,327 (between-person sleep duration and self-control). We separately report the between-person and within-person results.

Meta-analyses and meta-regressions

Figs. 2–7 provide forest plots summarizing the results of the bivariate meta-analyses (also see Table 2). Weighted mean correlations ranged from 0.14 (95% CI 0.07; 0.21) to 0.35 (95% CI 0.24; 0.45). Sleep duration and sleep quality were positively and statistically significantly related at both the between-individual level ($r = 0.17$, 95% CI = 0.04; 0.29) and within-individual level ($r = 0.32$, 95% CI = 0.21; 0.44). The wide prediction intervals (PIbetween −0.06; 0.40; PIwithin 0.19; 0.46), large I^2 statistics (98% and 57%, respectively) indicate likely moderation of both relations, while the Q-statistic was significant for between-individual study designs ($Q\ (7) = 470.35$, $p < .001$) but not for within designs ($Q\ (3) = 7.31$, $p = .06$).

Sleep quality and self-control weighted mean correlations were significant at the between-individual level ($r = 0.26$, 95% CI = 0.21; 0.31) and within-individual level ($r = 0.35$, 95% CI = 0.24; 0.45), suggesting that individuals who sleep poorly tend to show low levels of self-control (between-individual), and that one particular individual who sleeps poorly can show low levels of self-control (within-individual). The correlations tend to be stronger for within-individual studies than for between-individual studies. We once again observed substantial heterogeneity for both relations with wide prediction intervals ($PI_{between}$ 0.10; 0.42; PI_{within} 0.16; 0.54), large I^2 statistics (93% and 87%, respectively), and significant Q-statistics ($Q_{between}\ (28) = 353.64$, $p < .001$; $Q_{within}\ (8) = 78.49$, $p < .001$).

Next, sleep duration and self-control weighted mean correlations were significant at the between-individual level ($r = 0.14$, 95% CI = 0.07; 0.21) and within-individual level ($r = 0.20$, 95% CI = 0.09; 0.31). The findings suggest that sleep deprived individuals tend to show low levels of self-control (between-individual), and that one particular sleep deprived individual can show low levels of self-control (within-individual). Once again, the

[3] We also ran analyses after excluding studies that measured sleep for one month before (k = 11), which showed near identical results.

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Table 1
Summarized characteristics of included studies.

Author, year	Study # (in the focal article)	Between vs. within	Age	% female	Experiment vs. correlation	Cross-sectional vs. time-lagged	Sample size (individual)	Sleep: subjective vs. objective	Self-control: subjective vs. objective	Self-control: behavioral vs. non-behavioral	Sleep measure: a month	Published
Bagley, 2012 [40]	1	BW	NR	51%	COR	CS	1077	S (DR)	S	NB	N	N
Barber et al., 2013 [41]	1	BW	NR	77%	COR	CS	328	S (DR)	S	NB	Y	Y
Barnes et al., 2011 [42]	2	BW	NR	44%	COR	CS	80	S (DR)	S	NB	N	Y
Barnes et al., 2011 [42]	3	BW	37.37	49%	COR	CS	182	S (DR)	S	NB	N	Y
Baumeister et al., 2019 [19]	1	WT	44.00	62%	COR	CS	3237	S (QL, DR)	S	NB	N	Y
Bernier, 2010 [43]	1	BW	1.08	60%	COR	TL	60	S (DR)	O	B	N	Y
Brunet et al., 2020 [44]	1	WT	23.00	33%	EXP	TL	18	O (DR)	O	B	N	Y
Carleton, 2017 [45]	3	WT	50.10	69%	COR	CS	433	S (QL, DR)	S	NB	N	N
Cheng et al., 2020 [46]	1	BW	9 to 11	48%	COR	CS	11,067	S (DR)	S	NB	N	Y
Choshen-Hillel et al., 2021 [47]	1	BW	32.50	31%	COR	CS	51	S (QL)	O	B	N	Y
Christian and Ellis, 2011 [48]	1	BW	36.00	82%	COR	CS	171	S (DR)	S	NB	N	Y
Christian and Ellis, 2011 [48]	2	BW	21.50	48%	EXP	CS	75	O (DR)	O	B	N	Y
Clifford et al., 2020 [49]	1	WT	8.45	52%	COR	CS	534	O (DR)	S	NB	N	Y
Clinton et al., 2020 [50]	1	BW; WT	NR	59%	COR	CS	193	S (DR)	S	NB	N	Y
Conklin, 2013 [51]	1	BW	20.35	51%	COR	CS	199	S (QL)	S	NB	Y (QL)	N
Danböck and Werner, 2019 [52]	1	BW	23.58	70%	COR	CS	125	S (QL)	S	NB	N	Y
Demos et al., 2016 [53]	1	WT	37.00	71%	COR	TL	34	O (DR)	O	B	N	Y
Della Porta, 2013 [54]	1	BW	NR	66%	COR	CS	44	S (DR)	S	NB	N	N
Diestel et al., 2015 [55]	1	BW; WT	36.32	54%	COR	TL	63	S (QL)	S	NB	N	Y
Diestel et al., 2015 [55]	2	BW; WT	41.64	49%	COR	TL	108	S (QL)	S	NB	N	Y
Doan et al., 2018 [56]	1	BW	15.93	51%	COR	CS	47	S (QL)	S	NB	Y (QL)	Y
Evans and Norbury, 2021 [57]	1	BW	19.56	88%	COR	CS	191	S (QL)	S	NB	N	Y
Fairborn, 2010 [58]	1	BW	NR	51%	COR	CS	14,723	S (QL, DR)	S	NB	N	N
Fallone et al., 2001 [59]	1	BW	11.90	47%	EXP	TL	87	O (DR)	O	B	N	Y
Gamaldo et al., 2020 [60]	1	BW	66.58	77%	COR	CS	93	S (QL)	S	NB	N	Y
Goldschmied et al., 2015 [61]	1	WT	20.05	50%	EXP	TL	22	O (DR)	S	NB	N	Y
Gombert et al., 2018 [62]	1	BW; WT	39.50	57%	COR	CS	63	S (QL)	S	NB	N	Y
Goodwin et al., 2017 [63]	1	BW	35.68	70%	COR	CS	1619	S (DR)	S	NB	N	Y
Gruber et al., 2012 [64]	1	WT	8.68	41%	EXP	CS	16	O (DR)	S	NB	N	Y
Hisler, 2019 [65]	1	BW; WT	19.58	65%	COR	CS; TL	85	S (QL); O (DR)	S	NB	N	N
Hisler et al., 2019 [66]	1	WT	18.80	58%	COR	CS	211	S (DR)	S	NB	N	Y
Hong et al., 2020 [67]	1	BW	13.34	53%	COR	CS	1721	S (QL, DR)	S	NB	N	Y
Jenkins, 2005 [68]	1	BW	23.16	61%	COR	CS	410	S (QL, DR)	S	NB	N	N
Julian et al., 2019 [69]	1	BW	1.91	49%	COR	CS	171	S (DR)	O	B	N	Y
Jusienė and Breidokienė, 2019 [70]	1	BW	NR	49%	COR	TL	128	S (DR)	O	B	N	Y
Killgore, 2007 [16]	1	WT	23.50	46%	EXP	TL	54	O (DR)	S	NB	N	Y
Killgore et al., 2008 [71]	1	WT	25.30	19%	EXP	TL	26	O (DR)	S	NB	N	Y
Knapp, 2015 [72]	1	BW	34.50	55%	COR	CS	23	S (QL)	S	NB	Y (QL)	N
Kroese et al., 2016 [73]	1	BW	50.07	55%	COR	CS	2431	S (DR)	S	NB	N	Y
Kühnel et al., 2016 [74]	1	BW; WT	38.36	50%	COR	CS	154	S (QL, DR)	S	NB	N	Y
Kühnel et al., 2018 [75]	1	BW; WT	43.36	59%	COR	CS	66	S (QL, DR)	S	NB	N	Y
Liu et al., 2018 [76]	1	BW	16.75	47%	COR	CS	1196	S (QL)	S	NB	Y (QL)	Y
Liu et al., 2020 [77]	1	BW	32.50	63%	COR	CS	1507	S (QL)	S	NB	N	Y
Lundwall, 2011 [78]	1	BW	20.00	72%	COR	CS	554	S (QL)	S	NB	N	N
Massar and Chee, 2015 [79]	1	WT	22.28	45%	EXP	TL	29	O (DR)	O	B	N	Y
Masood et al., 2020 [80]	1	BW	NR	47%	COR	CS	701	S (QL)	S	NB	Y (QL)	Y
McGowan et al., 2020 [81]	1	BW	22.30	48%	COR	CS	188	S (QL)	O	B	N	Y
Nathanson and Beyens, 2018 [82]	1	BW	4.00	48%	COR	CS	402	S (DR)	S	NB	N	Y
Park et al., 2020 [83]	1	BW	38.96	48%	COR	CS	214	S (QL)	S	NB	N	Y
Przepiórka et al., 2019 [84]	1	BW	20.57	72%	COR	CS	315	S (QL)	S	NB	Y (QL)	Y
Schumacher et al., 2017 [85]	1	WT	3.80	58%	EXP	TL	19	O (DR)	O	B	N	Y
Seibert et al., 2019 [86]	1a	BW	35.17	100%	COR	CS	96	S (QL)	S	NB	Y (QL)	Y
Seibert et al., 2019 [86]	1b	BW	36.65	0%	COR	CS	96	S (QL)	S	NB	Y (QL)	Y
Van Eerde and Venus, 2018 [87]	1	BW; WT	35.20	49%	COR	CS	71	S (QL)	S	NB	N	Y
Vazsonyi et al., 2018 [88]	1	BW	17.54	49%	COR	CS	6866	S (QL, DR)	S	NB	N	Y
Wagner et al., 2012 [89]	2	BW	22.00	57%	COR	TL	96	O (DR)	O	B	N	Y
Weis et al., 2015 [90]	1	BW	25.60	74%	COR	CS	460	S (QL)	S	NB	Y (QL)	Y
Welsh et al., 2018 [91]	1	BW	22.10	46%	EXP	TL	160	O (DR)	S	NB	N	Y
Welsh et al., 2018 [91]	2	BW	36.80	51%	COR	CS	172	S (QL, DR)	S	NB	N	Y
Yaugher, 2017 [92]	1	BW	18.91	69%	COR	TL	87	O (DR)	O	B	N	N
Zhu et al., 2019 [93]	1	BW	19.29	51%	COR	CS	513	S (QL)	S	NB	Y (QL)	Y

Note. BW = between-individual level; WT = within-individual level; COR = correlational; EXP = experimental; CS = cross-sectional; TL = time-lagged; S = subjective; O = objective; QL = sleep quality; DR = sleep duration; B = behavioral; NB = non-behavioral; Y = yes; N = no.

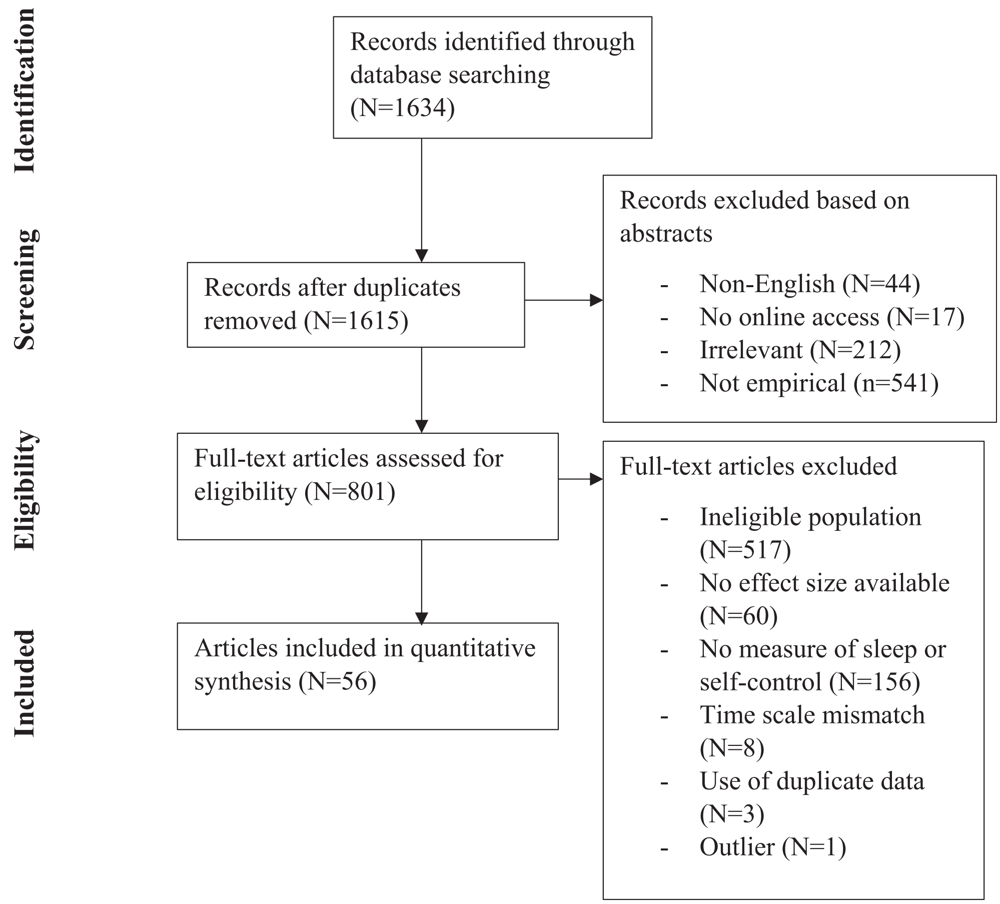

Fig. 1. PRISMA flow diagram of included studies Note. N= number of articles.

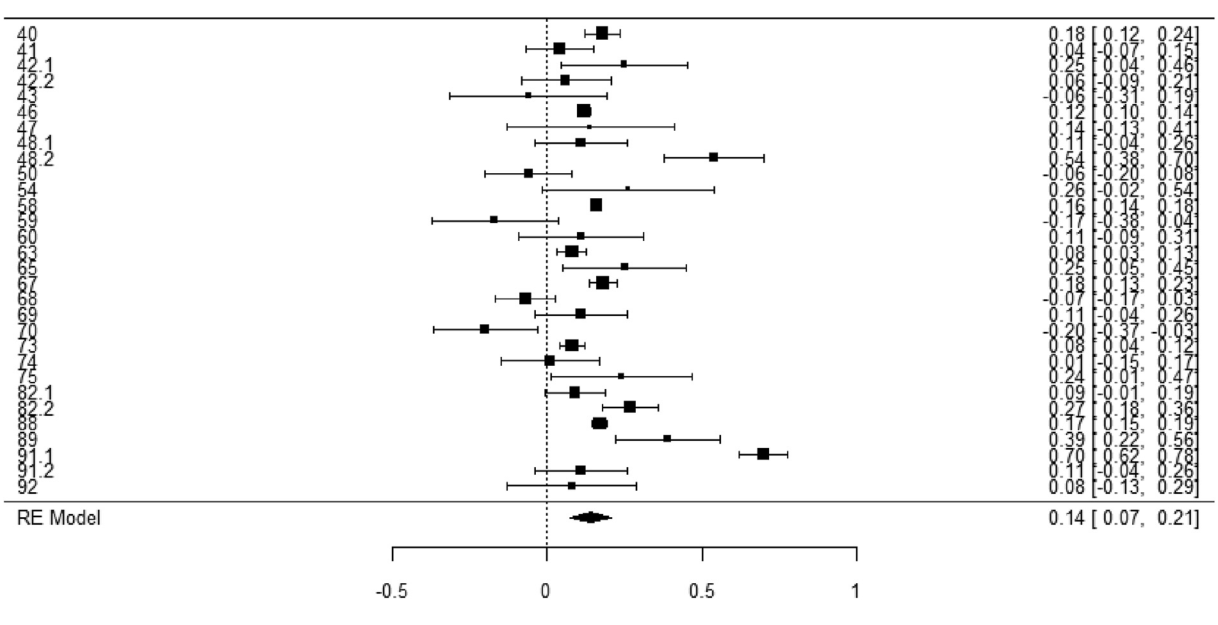

Fig. 2. Forest plot. Summary of the meta-analysis for the predictive value of sleep quality on self-control (between-individual level). Reference numbers on the left, coefficients with confidence intervals on the right.

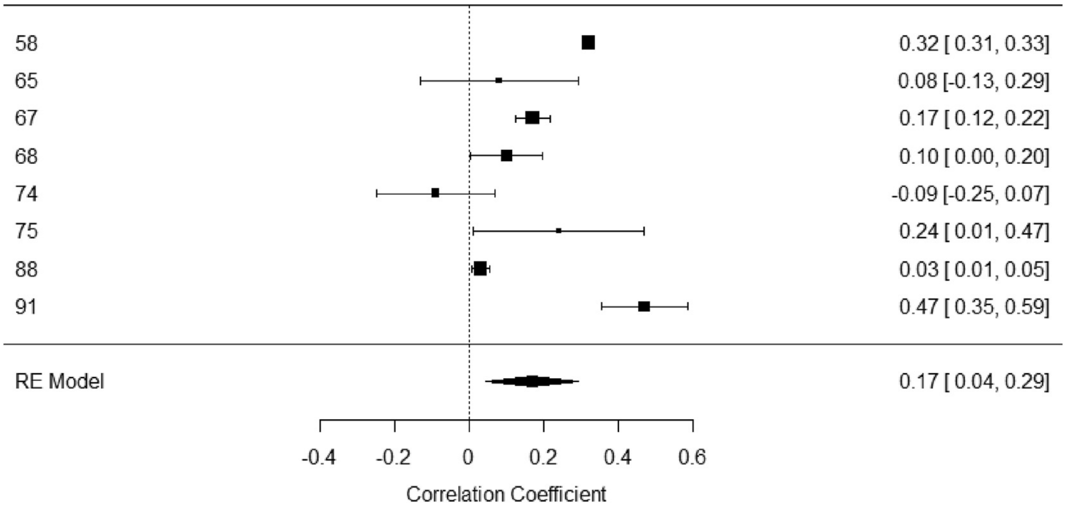

Fig. 3. Forest plot. Summary of the meta-analysis for the predictive value of sleep quality on self-control (within-individual level). Reference numbers on the left, coefficients with confidence intervals on the right.

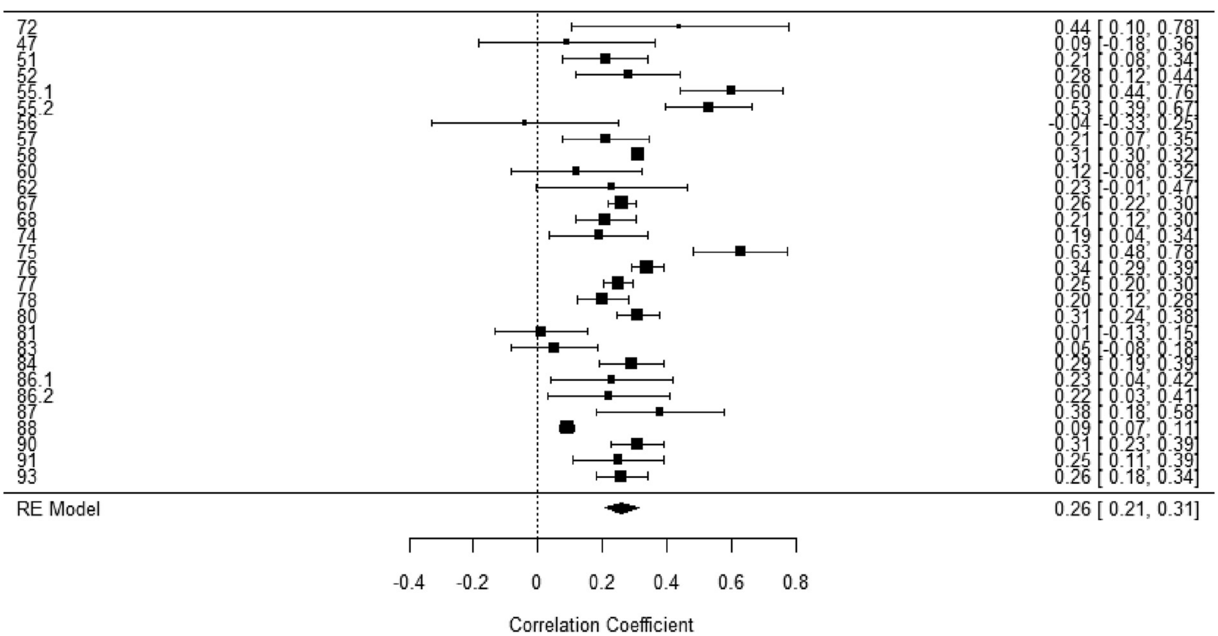

Fig. 4. Forest plot. Summary of the meta-analysis for the predictive value of sleep quantity on self-control (between-individual level). Reference numbers on the left, coefficients with confidence intervals on the right.

correlations were stronger in within-individual studies than in between-individual studies. We observed substantial heterogeneity for both relations with wide prediction intervals ($PI_{between}$ −0.08; 0.37; PI_{within} −0.15; 0.35), large I^2 statistics (97% and 86%, respectively), and significant Q-statistics ($Q_{between}$ (25) = 331.44, $p < .001$; Q_{within} (13) = 198.51, $p < .001$).

The relative weights analyses are presented in Table 3. Using a correlation matrix consisting of the three off−diagonal relations (i.e., sleep quality and sleep duration, sleep quality and self-control, and sleep duration and self-control), we determined the relative contribution of each sleep predictor. At the between-subjects level, sleep quality and sleep duration collectively accounted for 7.7% of the explained variance (R^2 = 0.077). However, the model was dominated by sleep quality (raw weight = 0.063; relative weight = 81.1% of the explained variance). Although sleep quality was the far more important predictor in that it explained more than four times the amount of variance in self-control than sleep duration (81.1% vs. 18.9%), it is still worth noting that sleep duration did explain some of the variance in self-control (raw weight = 0.015). This pattern of results was also found at the within-person level. Collectively, sleep duration and quality explained a substantial portion of the variance in self-control (R^2 = 0.131), but once again, sleep quality dominated the model (raw weight = 0.109; relative weight = 81.5%) while sleep duration played a significantly smaller role (raw weight = 0.024; relative weight = 18.5%).

All six relations were statistically significant, but there was also near universal evidence of excessive heterogeneity, which indicates that each of these relationships is likely moderated. Meta-regressions are presented in Table 4 (between-individual) and 5 (within-individual). Beginning with age, we did not find evidence that the mean

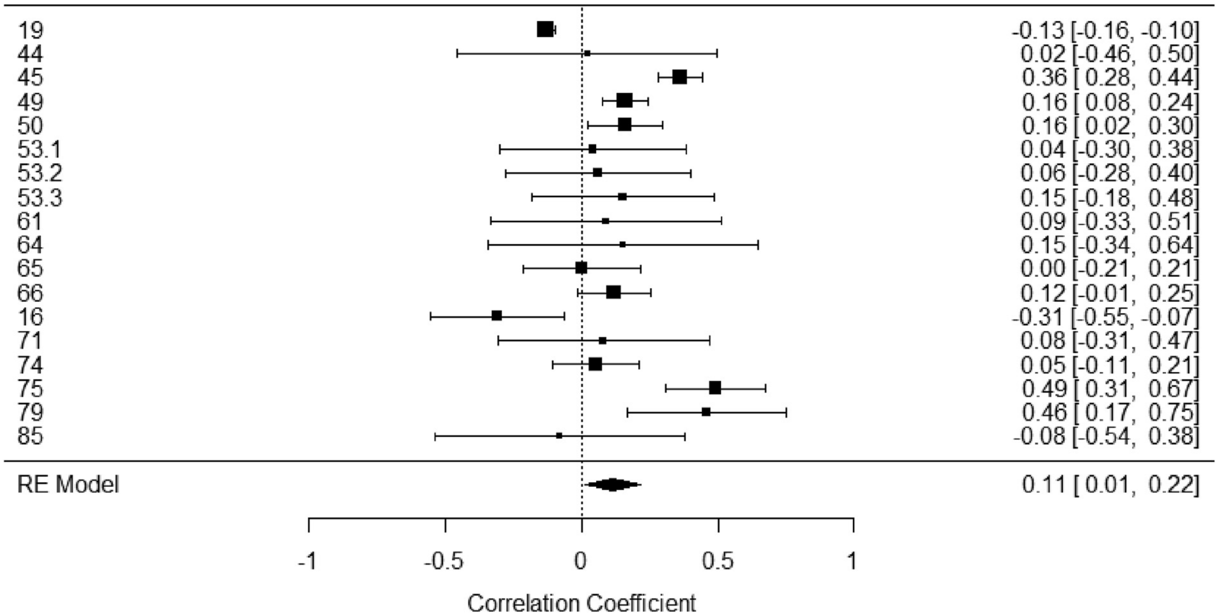

Fig. 5. Forest plot. Summary of the meta-analysis for the predictive value of sleep quantity on self-control (within-individual level). Reference numbers on the left, coefficients with confidence intervals on the right.

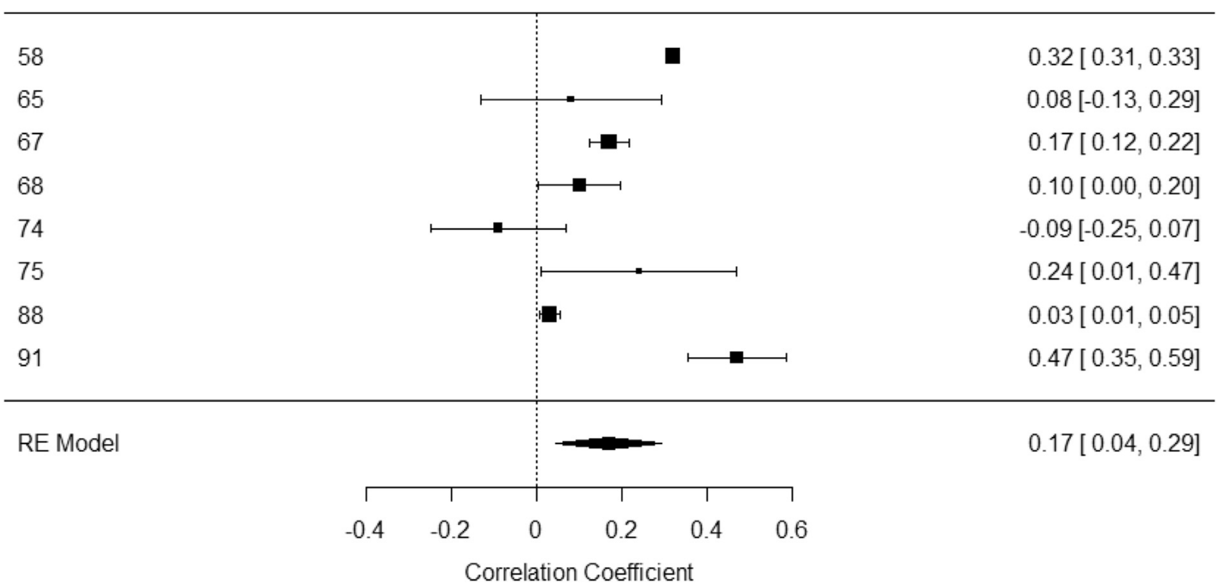

Fig. 6. Forest plot. Summary of the meta-analysis for the correlational value of sleep quality on sleep quantity (between-individual level). Reference numbers on the left, coefficients with confidence intervals on the right.

age of the sample moderated the between-individual relations, but we did find that age was a significant moderator of two of the three within-individual comparisons. Specifically, we found that as the mean age of the sample increased, the positive relations between sleep quality and sleep duration as well as sleep quality and self-control strengthened (b = 0.01, p = .02; b = 0.02, p = .01, respectively). Regarding gender, the proportion of females in the sample did not moderate any of the examined relationships. Moving onto design features, we were only able to examine the effect of experimental versus correlational studies for the between and within-individual sleep duration and self–control relationship. We found that the between-individual studies that utilized an experimental design did show a markedly stronger relationship than their correlational study counterparts (b = 0.34, p = .01), while study design had little effect on the within-individual studies. The only statistically significant difference of whether a study was cross-sectional or time-lagged appeared regarding the between-individual, sleep quality and self–control relationship: the time-lagged studies showed a stronger effect than the cross-sectional studies (b = 0.39, p = .002). In terms of variable operationalization, we observed no significant differences between how self-control was operationalized, but we did find that between-individual studies using an objective measure of sleep

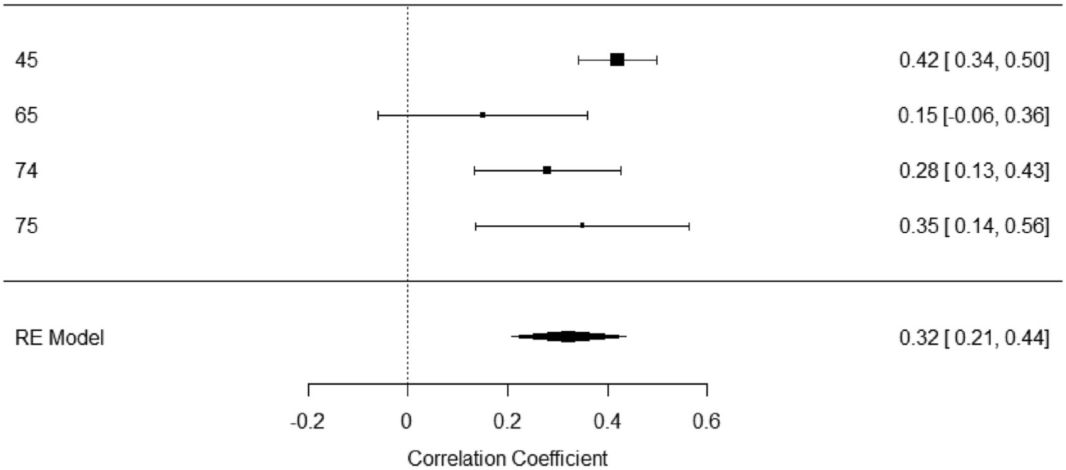

Fig. 7. Forest plot. Summary of the meta-analysis for the correlational value of sleep quality on sleep quantity (within-individual level). Reference numbers on the left, coefficients with confidence intervals on the right.

Table 2
Results of meta-analyses on correlations among sleep and self-control.

	k	n	$\bar{r}$	SE	95%CI	τ^2	I^2	Q	80%PI
Between-individual level									
Quality − Duration	8	24,197	0.17	0.06	0.04, 0.29	0.03	98%	470.35***	−0.06, 0.40
Quality − Self-control	29	30,986	0.26	0.03	0.21; 0.31	0.02	93%	353.64***	0.10; 0.42
Duration − Self-control	30	43,201	0.14	0.03	0.07; 0.21	0.03	97%	331.44***	−0.08; 0.37
Within-individual level									
Quality − Duration	4	738	0.32	0.06	0.21, 0.44	0.01	57%	7.31	0.19, 0.46
Quality − Self-control	9	4280	0.35	0.05	0.24, 0.45	0.02	87%	78.49***	0.16, 0.54
Duration − Self-control	18	5199	0.20	0.06	0.09; 0.31	0.03	86%	198.51***	−0.15; 0.35

Note. k = number of studies; n = number of individuals; $\bar{r}$ = weighted mean correlation; SE = standard error; CI = confidence interval around the mean correlation; τ^2 = between-study variance; I^2 = percentage of variance attributable to study heterogeneity; Q = Cochran's Q (with df = k-1); PI = prediction interval; Quality = sleep quality; Duration = sleep duration.

Table 3
Relative weight analysis for self-control.

	raw weight	relative weight	total R-square
Between subjects			
Sleep quality	0.063	81.1%	0.077
Sleep duration	0.015	18.9%	
Within subjects			
Sleep quality	0.109	81.5%	0.131
Sleep duration	0.024	18.5%	

duration reported significantly stronger effects on self-control ($b = 0.26$, $p = .01$) (see Table 5).

Across the six relationships, we examined whether studies with weak or opposite correlations were more likely to be excluded from the meta-analysis than studies that reported strong, opposite correlations that would create asymmetry in the funnel plot. We found no evidence of study suppression. Additional supplemental tests (e.g., cumulative meta-analytic drift, selection models) converged on similar findings and indicated a lack of evidence of publication bias.

Discussion

Despite the importance of self-control for everyday behaviors, the impact of sleep on controlling impulses and overcoming temptations, and the increasing amount of research investigating the relationship between sleep and self-control, to the best of our knowledge, no meta-analytic review has been conducted to summarize and consolidate the findings. Conducting a meta-analytic review is particularly relevant because the cumulative studies are spread across multiple disciplines, limiting our knowledge on the consolidated correlations between sleep and self-control. The present review is the first meta-analysis investigating the effects of sleep duration and sleep quality on self-control. We also investigated potential differences between the level of analysis (between-individual vs. within-individual), research design (experiment vs. correlation; cross-sectional vs. time-lagged), and type of measure (subjective vs. objective for sleep and self-control).

The findings of this meta-analysis suggest an overall association between sleep and self-control. Specifically, sleep quality is related to self-control at both levels of analyses (between-individual vs. within-individual). In general, between-individual analyses explain trait—level relationships, whereas within-individual analyses explain state—level relationships. Among the between-individual differences (trait-level), the relationship between sleep quality and self-control was stronger in time-lagged studies in comparison to cross-sectional studies, suggesting that measuring sleep quality and self-control at the same time decreased their correlation. In within-individual studies (or state-level studies), the relationship between sleep quality and self-control was stronger as the sample average age increased suggesting that in older samples the relationship between sleep quality and self-control was more pronounced. Perhaps, these findings suggest that individuals in older samples tend to engage in self-control more often than individuals in younger samples, but when individuals in older samples sleep poorly, they cannot regulate

Table 4
Results of moderator analyses (between-individual level).

	k	R^2	Q-residual	p-residual	b	SE	t	p-value	95%CI
Age									
Quality − Duration	7	0.00	66.11	0.00	0.00	0.01	0.65	0.55	−0.01, 0.02
Quality − Self-control	27	0.00	188.08	0.00	0.00	0.00	1.02	0.32	−0.00; 0.01
Duration − Self-control	23	0.00	169.50	0.00	0.00	0.00	−0.20	0.84	−0.01; 0.01
Gender: M = 0, F = 1									
Quality − Duration	8	0.00	431.84	0.00	0.35	1.31	0.27	0.80	−2.85, 3.55
Quality − Self-control	29	0.00	335.67	0.00	−0.03	0.18	−0.18	0.86	−0.40; 0.34
Duration − Self-control	30	0.00	196.99	0.00	0.33	0.35	0.96	0.35	−0.38; 1.04
Design: COR = 0, EXP = 1									
Duration − Self-control	30	0.30	165.89	0.00	0.34	0.12	2.93	0.01	0.10; 0.58
Time: CS = 0, TL = 1									
Quality − Duration	8	0.00	496.99	0.00	−0.10	0.23	−0.45	0.67	−0.66, 0.46
Quality − Self-control	29	0.43	315.03	0.00	0.39	0.11	3.52	0.00	0.16; 0.62
Duration − Self-control	30	0.00	206.96	0.00	0.05	0.09	0.49	0.63	−0.15; 0.24
Sleep: Sub = 0, Obj = 1									
Quality − Duration	8	0.00	497.99	0.00	−0.10	0.23	−0.45	0.67	−0.66, 0.46
Duration − Self-control	30	0.29	173.05	0.00	0.26	0.09	2.92	0.01	0.08; 0.43
Self-control: Sub = 0, Obj = 1									
Duration − Self-control	30	0.00	210.95	0.00	−0.04	0.09	−0.50	0.62	−0.23; 0.14

Note. k = number of studies; R^2 = Variance accounted for estimate; F-residual = Knapp-Hartung adjusted omnibus test of residual (unexplained) variance; p-residual = statistical significance of the unexplained moderators; b = unstandardized regression coefficient; SE = standard error; t = t-tests (with *df* = k-2); CI = confidence interval around the mean correlation; Quality = sleep quality; Duration = sleep duration; M = male; F= Female; COR = correlational; EXP = experimental; CS = cross-sectional; TL = time-lagged; Sub = subjective; Obj = objective.

Table 5
Results of moderator analyses (within-individual level).

	k	R^2	F-residual	p-residual	b	SE	t	p-value	95%CI
Age									
Quality − Duration	4	1.00	0.22	0.89	0.01	0.00	7.99	0.02	0.00, 0.02
Quality − Self-control	9	0.60	30.39	0.00	0.02	0.01	3.21	0.01	0.00, 0.03
Duration − Self-control	17	0.00	148.34	0.00	0.00	0.00	0.89	0.39	−0.00; 0.01
Gender: M = 0, F = 1									
Quality − Duration	4	0.00	5.02	0.08	−0.48	0.97	−0.49	0.67	−4.63, 3.68
Quality − Self-control	9	0.14	40.64	0.00	−1.06	0.84	−1.26	0.25	−3.04, 0.93
Duration − Self-control	18	0.00	168.63	0.00	−0.20	0.42	−0.47	0.64	−1.10; 0.70
Design: COR = 0, EXP = 1									
Duration − Self-control	18	0.00	168.89	0.00	−0.10	0.12	−0.83	0.42	−0.34; 0.15
Time: CS = 0, TL = 1									
Quality − Duration	4	0.59	2.96	0.23	−0.23	0.12	−1.91	0.20	−0.76, 0.29
Quality − Self-control	9	0.00	60.97	0.00	0.10	0.16	0.64	0.54	−0.27, 0.47
Duration − Self-control	18	0.02	168.54	0.00	−0.12	0.10	−1.26	0.23	−0.33; 0.08
Sleep: Sub = 0, Obj = 1									
Quality − Duration	4	0.59	2.96	0.23	−0.23	0.12	−1.91	0.20	−0.76, 0.29
Duration − Self-control	18	0.00	153.33	0.00	−0.12	0.10	−1.26	0.23	−0.31; 0.11
Self-control: Sub = 0, Obj = 1									
Duration − Self-control	18	0.00	165.72	0.00	0.02	0.12	0.14	0.89	−0.24; 0.27

Note. k = number of studies; R^2 = Variance accounted for estimate; F-residual = Knapp-Hartung adjusted omnibus test of residual (unexplained) variance; p-residual = statistical significance of the unexplained moderators; SE = standard error; t = t-tests (with *df* = k-2); CI = confidence interval around the mean correlation; Quality = sleep quality; Duration = sleep duration; M = male; F = female; COR = correlational; EXP = experimental; CS = cross-sectional; TL = time-lagged; Sub = subjective; Obj = objective.

their behavior. In addition, there was no difference based on study design or cross-sectional and time-lagged studies. At neither level, the relations differed by the proportion of females in the sample.

The results also suggest that sleep duration relates to self-control for between-individual (or trait-level) studies and within-individual (or state-level). Regardless of the level of analysis (between- or within-individual), the relationship between sleep duration and self-control did not vary based on average sample age or study design (cross-sectional or time-lagged). For between-individual design, the relationship between sleep duration and self-control was stronger when sleep duration was measured objectively instead of subjectively suggesting that how researchers operationalize sleep duration can influence the reported findings. Measuring sleep duration subjectively can be interpreted as a conservative operationalization. In addition, the relationship between sleep duration and self-control (between-individual) was also stronger when the study is experimental versus correlational suggesting that creating proper conditions for manipulating sleep duration can potentially strengthen the proposed relationships. Overall, the proportion of females in the sample did not influence the relationship between sleep duration and self-control. Moreover, measuring self-control objectively or subjectively did not influence the relationship between sleep duration and self-control.

Supplemental analyses of the relationship between sleep quality and duration showed that they are correlated at both levels of analysis (between-individual vs. within-individual). This correlation did not vary by study design (cross-sectional vs. time-lagged), whether sleep duration was measured objectively or subjectively, and the average gender of the sample. However, the relationship was stronger as the average sample got older for within-individual (state-level) studies. Finally, when modeled together, sleep quality explained more variance than sleep duration regardless of the level of analysis.

Future directions

Although the within-individual (state-level) correlation between sleep duration and self-control was significant in the predicted direction and none of our moderators was significant, significant p-residual suggested the potential presence of other moderators. One potential moderator is trait self-control, or individuals' general ability to control impulses and overcome temptations [30]. Individuals high in trait self-control may have a larger self-control reserve, which helps them handle dilemmas in more functional and productive ways [e.g., Ref. [31]]. It seems plausible that the relationship between state sleep duration and state self-control is moderated by trait self-control such as the relationship is more pronounced for individuals low in trait self-control. Future research should investigate the interaction between state sleep duration and trait self-control on state self-control.

Another potential moderator that can lead to future studies is conscientiousness. Conscientiousness is a personality trait related to self-discipline, deliberation, competence, order, dutifulness, and achievement striving [32], and it plays an important role in self-control [33]. For example, highly conscientious individuals have been shown to be less likely to procrastinate [presumably reflecting self-control; [34]]. Future research should investigate if the relationship between state sleep duration and state self-control varies as a function of consciousness. In addition, researchers could also investigate the role of age in both sleep and self-control. There were relatively few studies to artificially create categories (e.g., toddlers, teens, adults, etc.) and conduct analyses based on these categories. However, researchers and further investigate if the effects of sleep on self-control are different based on age groups. It is worth noting that, in meta-analyses, we can interpret results related to the mean age of the samples, and not age specifically.

Besides some individual traits, contextual factors could also explain the relatively large variability in the sleep duration and self-control meta-analytic estimate. Some situations, for example, may have clearly established rules that require little self-control. In those situations, sleep duration would have a weak impact on the individuals' ability to control impulses or overcome temptations. Future research should investigate if the presence of strong rules influences the strength of the relationship between state sleep duration and state self-control.

Although there is some indirect evidence suggesting that sleep influences self-control via pre-frontal cortex activity [e.g., Refs. [12,35,36]], we know little about the sequence of pre-frontal cortex activity that leads to dysfunctional levels of self-control. Researchers have shown that sleep disproportionally affects prefrontal cortex activity [9,10], and that the lateral prefrontal cortex is the "master" regulator region of our brain [15]. Nevertheless, researchers still need to empirically test the details of this potential physiological mechanism. Perhaps even more relevant is to specifically identify the region in the prefrontal cortex that sleep influences, which in turn affects self-control. In addition, future research can look into potential other alternative causal pathways. For example, is there another physiological causal path or multiple paths working together? Moreover, there remains the possibility that the effects of sleep on self-control are driven not only by decrements in activity in the prefrontal cortex, but more broadly across the frontoparietal executive control network. This systems-level view of sleep and executive function will likely reveal complex effects across multiple components of this system, as well as the potential for cascading effects across subcomponents of the executive control network system. This will be a very important avenue for future research.

There may be behavioral components such as poor sleep hygiene and bedtime procrastination which undermine sleep and have downstream effects on self-control. Relatedly, it may be that educational factors drive these behavioral factors, with many people unaware of how to engage in healthy sleep practices. Indeed, there may even be authority figures who are promoting practices which undermine sleep and thereby self-control [37], highlighting the importance of role models as psychological factors relevant to this topic. Moving to a more macro perspective, there may also be cultural practices which de-emphasize the importance of sleep, which have downstream implications for self-control.

There are potentially important effects of circadian rhythms that may also be useful for future study. This includes not only the time of day of the task requiring self-control, but also the time of day in which the person sleeps. Moreover, the match between the time of day and the individual's chronotype may be important. It may be that above and beyond the effects of sleep duration and quality, such chronotype and circadian effects influence self-control. These are all areas which need future research to elucidate the effects in question as well as eventually seek solutions to these issues.

Finally, a potentially fruitful area for future research is the impact of sleep interventions as a means to improve self-control-related outcomes. Researchers have found that individuals who treated insomnia with an internet-based cognitive behavior therapy experienced improvements in self-control [38]. In a different study, researchers found that wearing blue-light filtering glasses influenced sleep duration and quality, which in turn resulted in higher levels of job attitudes and performance [39]. We encourage researchers to investigate other potential interventions, such as sleep hygiene practices, bedding thermo-regulation, and acoustic stimulation as potential ways to improve sleep and self-control outcomes.

Conclusion

The current review examines the interplay between sleep and self-control. The results provide evidence that sleep quality, and sleep duration are related to self-control. Despite the level of analysis (between-individual vs. within-individual), research design (experiment vs. correlation; cross-sectional vs. time-lagged), and type of measure (subjective vs. objective for sleep and self-control), in general, sleeping less or poorly inhibits the individuals' ability to exert self-control. Considering that self-control is key for living a functional and productive life and that sleep affects self-control, a future research agenda should include a deeper investigation into the causal process (potentially via prefrontal cortex activity) linking sleep and self-control, and an examination of the moderators (individual and contextual variables) that could impact the relationship between sleep and self-control.

Practice points

- People who tend to sleep less, and sleep worse tend to have less self-control; sleeping more and sleeping better on average will lead to better self-control
- A given individual who sleeps more and well will tend to have more self-control
- The evidence indicates that, overall, self-control outcomes can be aided by sleep
- We recommend sleeping well before engaging in behaviors that can potentially be influenced by impulses and temptations

Research agenda

- Deeper investigation into the causal processes by which sleep influences self-control
- Deeper and broader investigation into potential person-based and situation-based moderators of the effect of sleep on self-control
- Examination of differential mediators and moderators across the effects of sleep duration, and sleep quality on self-control
- Examination of individual differences related to circadian processes and how it relates to self-control

Conflicts of interest

The authors do not have any conflicts of interest to disclose.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.smrv.2021.101514.

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