A systematic review and meta-analysis to assess the relationship between sleep duration/quality, mental toughness and resilience amongst healthy individuals

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Summary

The majority of sleep research has focused on deleterious health outcomes, with little attention to positive sequels. A systematic review of the literature regarding sleep duration and/or sleep quality in relation to mental toughness and resilience amongst non-clinical, healthy populations was completed. Eight databases and selected sources for grey literature were searched from their inception to April 2021. A total of 1,925 unique records (1,898 from the database search and 27 from grey sources) were identified and screened against the pre-set inclusion and exclusion criteria. Of these, 68 studies were eligible and 63 were included in the meta-analysis. Pooled results indicated a weak, positive correlation between sleep duration and resilience ($r=0.11$, $p<0.001$), and sleep quality ($r=0.27$, $p<0.001$). The pooled correlation was slightly attenuated for prospective studies pertaining to sleep quality and resilience ($r=0.18$, $p<0.001$). We found evidence of high publication bias for studies that explored the relationship between sleep quality and resilience. Sleep and resilience are positively correlated but additional research is needed to verify the direct relationship through carefully designed, prospective studies that capture both subjective and objective sleep estimates. For a more comprehensive understanding, complementary reviews that explore the sleep-resilience association are needed for clinical populations, and those who have suffered extreme hardship.

Keywords: meta-analysis; resilience; sleep duration; sleep quality; systematic review.

Abbreviations: Connor-Davidson resilience scale (CD-RISC); insomnia severity index (ISI); mental toughness questionnaire (MTQ); Pittsburgh sleep quality index (PSQI); preferred reporting items for systematic reviews and meta-analyses (PRISMA); slow wave sleep (SWS).

Introduction

Sleep is a reversible state with a naturally recurring period of reduced or absent consciousness. During sleep individuals have a decreased sensory response, and relative immobility, during which many physiological processes are impacted. These include a wide array of metabolic, inflammatory, neurologic, and other systems. Because of this, many prior studies have focused on the various downstream adverse effects of suboptimal sleep health. For example, outcomes such as insufficient sleep duration, inadequate sleep quality, and/or sleep disorders have been shown to be consistently associated with obesity (1), cardiovascular disease (2), metabolic dysregulation (3), pain (4), cancer (5), depression and anxiety (6), reduced quality of life (7), impaired neurocognitive function (8), as well as other outcomes, including mortality (9). Less attention, though, has been given to the positive impacts of sleep.

The concept of resilience – a "dynamic process of maintaining positive adaptation in the face of adversity" (10) has been identified as a transdiagnostic protective factor. Resilience and 'mental toughness' are similar concepts and the two terms are used interchangeably in our review. Resilience and mental toughness convey benefits across the lifespan, from childhood (11) to older adulthood (12), and it is implicated as a positive influence in outcomes as diverse as infectious disease (13), cardiometabolic health (14), cancer (15), pain (16), and mental and cognitive health (17). As mentioned above, many of these processes are also, in some way, related to sleep.

Previous systematic reviews have linked resilience to outcomes pertaining to cardiovascular health (18), mental health (19), and more. Similarly, previous systematic reviews have linked sleep to similar sets of outcomes (20-23). There are no previous systematic reviews, however, that have explored the links between resilience and sleep. Such an undertaking would address an important gap and contribute to the literature demonstrating how optimal sleep features are potentially associated with beneficial outcomes, as opposed to the predominant focus on poor sleep and adverse outcomes. This gap has been identified by multiple position statements (24-28). In addition, since sleep is often a modifiable behavior, understanding the benefits of improved sleep (beyond simply amelioration of adverse outcomes) may aid in the development and delivery of targeted interventions (29) and may also support the idea that improved sleep may even be beneficial for people without adverse outcomes in need of ameliorating. Before this work can be undertaken, however, the relationship between sleep and resilience needs to first be established. For this reason, the present study presents a systematic review and meta-analysis of the literature surrounding the cross-sectional and longitudinal relationships between sleep duration and sleep quality in relation to psychological resilience. We hypothesized that there would be a positive relationship between sleep duration and/or sleep quality and psychological resilience in non-clinical populations amongst pediatric and adult populations.

Methods

Study design

Our systematic review and meta-analysis was developed to assess the potential relationship between both sleep duration and sleep quality in relation to psychological resilience across healthy pediatric and adult populations, drawn from the general population. Our study protocol is registered on the international database, PROSPERO (CRD42020191119). Our work adheres to the new, 2020 preferred reporting items for systematic reviews and meta-analyses (PRISMA) statement (30).

Search strategy

A comprehensive literature search was conducted by a medical librarian (LÖ) in June 2020 and updated in April 2021. Eight databases: PubMed, Embase, APA PsycINFO, PsycArticles, CINAHL, Scopus, Web of Science and Academic Search Complete and sources for grey literature (Open Grey, OAlster, Grey Literature Report and Bielefeld Academic Search Engine-BASE) were covered by the search. Pre-searches in PubMed and PubMed's MeSH to identify relevant search terms and search techniques was performed in March-June 2020. A pilot screening of the result from the pre-search result in PubMed was conducted by two reviewers (TA & AA) before the search string was finalized and systematically applied in all selected databases.

A combination of the search fields: "title", "abstract" and "MeSH"/"thesaurus" was used for all search terms. No filters or limitations were added to ensure the best possible information retrieval and the inclusion of pre-indexed materials. Hand screening of reference lists from the included studies were also conducted (TA). Experts in the field (n=3) were also contacted to identify any further articles which were not captured by the search.

The records identified in the literature search were uploaded to the systematic review software, Covidence (Veritas Health Innovation, Melbourne, Australia. Available at www.covidence.org) for automatic de-duplication and blinded screening. Cabell's Predatory Report (31) was consulted to confirm the academic status of all included open-access papers.

A search log with results, reproducible search strings and notes for all databases and grey sources is available in Appendix A.

Articles captured by the search, after duplicates were removed, were independently screened by two authors (IG & AA) against the pre-defined inclusion and exclusion criteria. Conflicts identified by the software were resolved by a third author (TA). Two-hundred and ten full-text articles remained after the title and abstract screening. These were screened independently in Covidence by two authors (AA & IG) and discrepancies were resolved (TA).

Eligibility criteria

Studies were included if they met the following inclusion criteria:

1. Human sample;
2. Non-clinical population (pregnant and menopausal women who were otherwise healthy were also included);
3. Original research data;
4. Reported at least one measure of sleep duration and/or sleep quality (sleep onset latency, wake after sleep onset, night awakenings, sleep efficiency, sleep disturbance, insomnia symptoms, or a score from a validated tool to assess sleep quality);
5. Observational study;
6. Used at least one measure of mental/psychological resilience;
7. Reported on the direct relationship between sleep and resilience.

All articles that met the above criteria were included in our systematic review. For articles that included a measure of flourishing, if there was a sub-component of resilience for the measure and the direct relationship was reported for sleep quality/quantity and resilience then it was included. For articled that employed a flourishing scale which did not have a resilience component, then the article was not included as it was not specifically estimating levels of resilience. For articles that acquired data from non-clinical samples but screened for health conditions, the article was included providing all other criteria were met. If an article met the above inclusion criteria but had not reported on the direct relationship between sleep and resilience, the corresponding author of the published manuscript was contacted by email to request statistical information for inclusion in our review. Authors were contacted up to three times. If the author responded with the requested statistical information the article was included, otherwise the paper was excluded. Published conference abstracts without an accompanying full text, as well as dissertations/theses, or articles that lacked important methodological details were not included in the meta-analysis. Articles that ascertained data using ambiguous measures for sleep and/or resilience where the scales were not well described and interpretation of the scale scores were not provided were included in the systematic review but not in the meta-analysis.

Exclusion criteria

The following exclusion criteria were employed during the screening process:

1. Animal studies;
2. Clinical populations i.e. those with diagnosed mental/physical/sleep disorders;

3. Qualitative studies;
4. Reviews of any kind;
5. Letters to editor/editorials/comments/commentary/reports/correspondence, unless original research data was reported;
6. Experimental studies;
7. Infants (up to 12 months) as there is no validated tool to assess resilience in this age group;
8. Participants who were subjects of abuse (drugs, domestic, emotional and child) or children of parents with abuse issues (drugs, domestic, violence, emotional, physical);
9. In vitro/genetic studies;
10. Protocol papers;
11. Case studies;
12. Questionnaire validation studies.

Data extraction

All data were independently extracted by two blinded reviewers (TA & IG). A data extraction form was populated by the two authors and discrepancies were resolved by the team's statistician (OMO). The corresponding author of articles which did not present the data needed during the extraction process but were otherwise eligible were contacted for relevant statistical information. The data extracted included the following:

1. First author and year published;
2. Country where the study was conducted;
3. Sample size and unique sample characteristics;

4. Gender split (%);
5. Age (year) with measure of central tendency, if presented;
6. Sleep outcome and measure used;
7. Resilience measure used;
8. Confounders adjusted for in the formal analysis, as appropriate;
9. Study design;
10. Effect size and p value.

Quality assessment and risk of bias

All included articles were assessed for quality. We used the Study Quality Assessment tool for Observational Cohort and Cross-Sectional Studies from the National Institutes of Health (32). Quality assessment and risk of bias, of the studies that met our pre-defined inclusion criteria, was conducted independently by two authors (TA & IG). Discrepancies were resolved by a third author (MG). It was unclear if included abstracts, without a published full-text, were peer-reviewed therefore these were rated as ‘poor’ due to limited methodological and/or statistical detail.

Statistical analyses

Meta-analyses were performed separately for sleep duration and sleep quality. Random-effects models (DerSimonian-Laird method) (33) were used to calculate the overall effects from effect sizes due to evidence of high level of heterogeneity. Between-study heterogeneity was assessed using I-square (I^2) test (34). Prospective study designs are less susceptible to bias, a priori subgroup analysis was performed to explore the impact of prospective study design on the effect size. Heterogeneity between subgroups was evaluated using random-effect model. As studies reported different types of effect sizes, all effect sizes were transformed to Pearson's correlations (35). Hence, the overall effect size is expressed in terms of Pearson's correlation coefficient ranging from -1 to 1. A value of 0 indicates that there is no association between the two variables. A value greater than 0 indicates a positive association and a value less than 0 indicates a negative association. Publication bias was assessed visually using a funnel plot. Analyses were carried out using Stata 16 (StataCorp LP, USA). Two-sided p-values of <0.05 were considered statistically significant.

Results

A total of 3,866 articles were captured by the literature search. Of these, 1,941 were duplicates and were removed using Covidence and hand screening (search result from grey sources), leaving a total of 1,925 unique records for screening. A total of 68 studies were identified eligible to be included in the review, including a total of 131,820 individuals. Of the 68 studies, five were excluded from the meta-analysis (abstracts without full-text), leaving 63 that were included in the meta-analysis. No additional, relevant studies were identified in the systematic hand screening of the reference lists in the included studies or through contacting experts in the field. A PRISMA flow diagram with the details of the screening and selection process is shown in Figure 1.

INSERT FIGURE 1 HERE

Figure 1: PRISMA flow diagram demonstrating the systematic screening and selection processes based on updated guidelines for reporting systematic reviews (30)

A summary of all studies that met our criteria, as well as the quality of each, are depicted in Table 1.

Table 1: Details of studies included, extracted data and quality assessment

First author (year)	**Country**	**Sample size**	**Gender**	**Age in years (CT)**	**Sleep outcome (measure)**	**Resilience measure**	**Study design**
An (2018) (36)	Korea	263 (nurses)	95.8% female	30.09 (7.51)	Sleep quality (PSQI)	K-CD-RISC	Cross-sectional**
Алехин (2021) (37)	Russia	93	Not reported	Not reported	Sleep quality (ISS)	Unclear	Cross-sectional*
Arbinaga (2018) (38)	Spain	116 (dance students)	83.6% female	21.16 (4.35)	Sleep quality (PSQI); sleep duration (PSQI)	RS	Cross-sectional***
Sadeghi Bahmani (2016) (39)	Switzerland	77	58% male	BL: 5.4 (0.44); FU: 14.35 (1.22)	Sleep quality (ISI)	MTQ18	Longitudinal (9-year FU)***
Bozdag (2020) (40)	Turkey	214 (healthcare workers)	56.1% female	33.29 (6.82)	1 question for sleep quality (5-point Likert scale)	BRS	Cross-sectional**
Brand (2014a) (41)	Switzerland	284	65.2% female	18.26 (4.17)	Sleep quality (PSQI & ISI); sleep duration (PSQI)	MTQ48	Cross-sectional***
Brand (2014b) (42)	Switzerland	92	35% female	18.92 (4.17)	Sleep quality (EEG &	MTQ48	Cross-sectional***

					ISI); sleep duration (EEG)		
Brand (2015a) (43)	Switzerland	37	55.22% female	14 (1.3)	Sleep quality (EEG & ISI)	MTQ48	Longitudinal (9-year FU)***
Brand (2015b) (44)	Switzerland	346	54.6% female	23.87 (1.93)	Sleep quality (PSQI & ISI)	MTQ18	Cross-sectional***
Brand (2016) (45)	Switzerland	1,475	48.8% males	11-16	Sleep quality (ISI)	MTQ48	Cross-sectional***
Brand (2017)^ (46)	Switzerland	1,361	51.2% female	11-16	Sleep quality (ISI)	MTQ48	Cross-sectional***
Chang (2019) (47)	Taiwan	2,280	50.4% male	Grade 2-11	Sleep quality (PSQI, single item)	ARS	Longitudinal (annual follow-up for 9 years)***
Chatburn (2014) (48)	Not stated	61	52% male	7-18	Sleep quality (SDSC)	RSCA	Cross-sectional**
Cheng (2020) (49)	China	653	48.1% male	55.62 (9.51)	Sleep quality (AIS)	CD-RISC	Cross-sectional***
Constantino (2020) (50)	United States	42	63% female	60+	Sleep quality (PROMIS)	CD-RISC-10	Cross-sectional**
Cooper (2019) (51)	Not stated	Study 1: 181 (athletes)	Not stated	Not stated	Sleep duration (self-report) & sleep quality (RCSQ)	MTI	Cross-sectional***
Cramer (2016) (52)	United States	213 (clinicians & trainees)	73% female	28.3 (8.9)	Sleep quality (PROMIS sleep disturbance short form)	BRS	Cross-sectional***
Du (2021) (53)	7 countries	2,254 (students)	66.7% female	22.5 (5.5)	Sleep quality (PSQI);	BRS	Cross-sectional***

					sleep duration (PSQI)		
Gerber (2015)^ (54)	Switzerland	56 (students)	52% male	18.1 (1.2)	Sleep quality (PSQI & ISI)	MTQ48	Cross-sectional**
Graham (2020) (55)	Canada	12 (ultra-marathon runners)	75% male	42 (5.35)	Sleep duration (sleep log)	MTQ18	Longitudinal (3 days)***
Grossman (2021) (56)	Israel	243 (older adults)	69.1% female	69.76 (6.69)	Sleep quality (2 adapted from the ISI and 1 adapted from the PHQ-9)	CD-RISC	Cross-sectional***
Haghighi (2019) (57)	Iran	207 (medical students)	51.2% male	22.04 (2.75)	Sleep quality (ISI)	MTQ48	Cross-sectional**
Hrozanova (2019) (58)	Norway	632 (athletes)	50.2% male	18 (0.9)	Sleep quality (PSQI)	RS	Cross-sectional***
Huang (2020)^ (59)	China	1,597	22.79% male	24.34 (5.76)	Sleep quality (single item)	RS-14	Cross-sectional*
Hughes (2015)^^ (60)	United States	2,597 (military veterans)	80.4% male	37.2	Sleep quality (PSQI)	CD-RISC	Cross-sectional*
Jahangard (2017)^ (61)	Iran	206	57.3% male	18-24	Sleep quality (ISI)	MTQ48	Cross-sectional**
Jatachavala (2019) (62)	Thailand	245 (medical doctors)	58% female	35.9 (9.5)	Sleep quality (single item)	Thai-RQ	Cross-sectional*

Jeon (2017) (63)	Korea	1,794	86.4% female	29.8 (6.4)	Sleep quality (PSQI)	CD-RISC	Cross-sectional***
Jeong (2019) (64)	Korea	373 (nurses)	100% female	33.26 (9.55)	Sleep quality (PSQI & ISI)	CD-RISC	Cross-sectional***
Jin (2020) (65)	South Korea	582 (workers)	73.02% female	35.0 (8.03)	Sleep quality (SQS)	CD-RISC	Cross-sectional***
Kegelaers (2021) (66)	Not stated	163 (musicians)	80.4% male	32.85 (7.76)	Sleep quality (PROMIS sleep disturbance short form)	CD-RISC-10	Cross-sectional**
Laborde (2015) (67)	Not stated	1,950 (976 non-athletes & 974 athletes)	50.5% females (non-athletes); 49.1% females (athletes)	22.49 (non-athletes); 21.21 (athletes)	Sleep duration (single item); Sleep quality (single item)	Short-form RS	Cross-sectional***
Lang (2019)^ (68)	Switzerland	864 (students)	57% male	17.98 (1.36)	Sleep quality (PSQI & ISI)	MTQ18	Longitudinal (10-month FU)***
Lee (2016) (69)	Korea	1,094 (college students)	87% male	22.8 (1.9)	Sleep quality (PSQI)	CD-RISC-10	Cross-sectional***
Lee (2019) (70)	Korea	923 shift workers & 850 non-shift workers	3.9% male shift workers; 24.1% male non-shift workers	27.49 (4.22)	Sleep quality (PSQI)	CD-RISC	Cross-sectional***
Lei (2021) (71)	China	500 (frontline community workers)	64.4% male	38.7 (10.3)	Sleep quality (PSQI)	CD-RISC-10	Cross-sectional***

Li (2016) (72)	China	231 (healthy pregnant women)	100% female	26.58 (2.73)	Sleep quality (PSQI)	CD-RISC-10	Cross-sectional**
Li (2019) (73)	China	1,065 (college students)	49.67% males	20.21 (1.35)	Sleep quality (PSQI)	CD-RISC	Cross-sectional***
Li (2020) (74)	China	227 (university students)	76.7% female	17.85 (0.54)	Sleep quality (PSQI)	MTI	Longitudinal (3-month FU)***
Lind (2017) (75)	United States	133 (veterans)	88.5% male	29.8 (4.7)	Sleep quality (PSQI)	CD-RISC-10	Cross-sectional***
Liu (2016) (76)	China	1,471	55.5% male	34.5 (10.4)	Sleep quality (PSQI)	CD-RISC-10	Cross-sectional***
Lovstad (2020) (77)	Norway	30 (terror attack survivors)	63.3% female	26.7 (11.2)	Sleep quality (ISI; 5 items)	RSA	Cross-sectional***
Meers (2018)^^ (78)	United States	229	50.9% female	11.34 (2.92)	Sleep quality (1-week wrist actigraphy & sleep logs)	RSCA	Cross-sectional*
Mon-Lopez (2020) (79)	Spain	187 (handball players)	64.7% male	23.61 (6.19)	Sleep duration (1 question, hours); sleep quality (1-10 Likert scale)	BRS	Cross-sectional**
Natvik (2011) (80)	Norway	1,505 (nurses)	100% female	33.9 (9.6) for 2 rotating shifts; 32.2 (7.7)	Sleep quality (BIS)	Revised Norwegian Short Hardiness Scale	Cross-sectional***

				for 3 rotating shifts			
Reshadat (2018) (81)	Iran	400 (pregnant women)	100% female	18+	Sleep quality (PSQI)	CD-RISC	Cross-sectional**
Roberts (2017) (82)	United States	70 (parents of children with ASD)	100% female	Not stated	Sleep quality (CSHQ)	FIRA-G	Cross-sectional***
Rosenberg (2014) (83)	United States	95 (caregivers to children with cancer)	79% female; 18% male; 3% other	42 (7)	Sleep quality (single item)	CD-RISC-10	Cross-sectional***
Salah (2021) (84)	94 countries	3,816	28.9% male	38.6 (14.0)	Sleep quality (rated before and during COVID pandemic using 4-point Likert scale)	BRS	Cross-sectional**
Sim (2019) (85)	Korea	197 (nurses)	Not stated	48.7% in 20's	Sleep quality (PSQI)	K-CD-RISC	Cross-sectional*
Sinclair (2019) (86)	United States	333 (military spouses)	Not stated	49.3% were 30+	Sleep quality (ISI: sum of three items)	BRS	Cross-sectional***
Sobstad (2020) (87)	Norway	1,147 (nurses)	89% female	34.5 (8.3)	Sleep quality (BIS)	DRS-15	Longitudinal (3-year FU)***
Springfield (2020) (88)	United States	77,395	100% female	77 (6.4)	Sleep duration (1 question)	BRS	Cross-sectional***
Storemark	Norway	700 (nurses)	91.5% female	34.5 (7.8)	Sleep quality (BSWSQ)	HARDY (revised)	Longitudinal (2-year FU)***

(2013) (89)							
Thurston^^ (2021) (90)	US	32 (adolescents & primary caregiver)	69% female	11-17	Sleep duration (ASWS-SF)	CYRM	Cross-sectional*
Varma (2021) (91)	63 countries	1,653	30.3% male	42.90 (13.63)	Sleep quality (PSQI)	BRCS	Cross-sectional**
Wang (2020a) (92)	China	1,299 (students); 840 with complete FU data	58% female	15.79	Sleep quality (PSQI)	CD-RISC-10	Longitudinal (2-year FU)***
Wang (2021) (93)	China	1,591	100% female	43.80 (8.53)	Sleep quality (PSQI)	CD-RISC	Cross-sectional***
Wang (2020) (94)	China	1,193 (nurses)	Not stated	Not stated	Sleep duration (questions not specified)	CD-RISC	Cross-sectional*
Williams (2016)^ (95)	United States	1,939 (soldiers)	62% male	17-24 (88%)	Sleep quality (adapted four items)	CD-RISC-2	Longitudinal (3, 6 & 9-week FU)**
Xie (2020) (96)	China	1,213 (older adults)	Not stated	60+	Sleep quality (AIS)	SRQS	Cross-sectional***
Yang (2015) (97)	China	981 (students)	54% male	13.25 (0.66)	Sleep quality (PSQI)	RS	Longitudinal (3-year FU)***
Yang (2020) (98)	China	1,756 (migrant workers)	34.8% male	16-65	Sleep quality (PSQI)	CD-RISC	Cross-sectional***
Ye (2013) (99)	China	556 (soldiers); 571 (university students)	100% male	Not stated	Sleep quality (PSQI)	RS	Cross-sectional*

Yu (2020) (100)	New Zealand	93 (intensive care nurses)	73.1% female	33.9 (9.6)	Sleep quality (single item based on past month & 2 nights accelerometry); sleep duration (single item & 2 nights accelerometry)	CD-RISC	Cross-sectional***
Zhang (2020) (101)	China	180 (pregnant women)	100% female	20+	Sleep quality (PSQI)	CD-RISC	Cross-sectional**
Zhou (2016)^^ (102)	China	71 (college students)	72% female	19.92 (1.21)	Sleep quality (PSQI)	RS	Cross-sectional*
Zhou (2021) (103)	China	4,531 (1st year college students)	70.2% male	19.20 (1.77)	Sleep quality (PSQI)	CD-RISC	Cross-sectional***

AIS = Athens Insomnia Scale; ARS = Adolescent Resilience Scale; ASD = Autism Spectrum Disorder; ASWS-SF = Adolescent Sleep-Wake Scale-Short Form; BIS = Bergen Insomnia Scale; BL = Baseline; BRCS = Brief Resilience Coping Scale; BRS = Brief Resilience Scale; BSWSQ = Bergen Shift Work Sleep Questionnaire; CD-RISC = Connor-Davidson Resilience Scale (25 items); CD-RISC-2 = Connor-Davidson Resilience Scale (2 items); CD-RISC-10 = Connor-Davidson Resilience Scale (10 items); CSHQ = Child Sleep Habits Questionnaire; CT = Central Tendency; CYRM = Child and Youth Resilience Measure; DRS-15 = Dispositional Resilience Scale (15 items); EEG = Electroencephalography; FIRA-G = Family Index of Regenerativity and Adaptation – General; FU = Follow up; HARDY = Dispositional Resilience (Hardiness) Scale; ISI = Insomnia Severity Index; ISS = Insomnia Severity Scale; K-DC-RISC = Korean Connor-Davidson Resilience Scale; MTI = Mental Toughness Index; MTQ18 = Mental Toughness Questionnaire (18 items); MTQ48 = Mental Toughness Questionnaire (48 items); OR = Odds Ratio; PROMIS = Patient-Reported Outcomes Measurement Information System; PSQI = Pittsburgh Sleep Quality Index; RCSQ = Richards-Campbell Sleep Questionnaire; RS = Resilience Scale; RS-14 = Resilience Scale (14 items); RSCA = Resiliency Scale for Children and Adolescents; SDSC = Sleep Disturbance Scale for Children;

SQS = Sleep Quality Scale; SRQS = Stress Resilience Quotient Scale; Thai-RQ = Thai Resilience Questionnaire.

^Data provided by the author (not reported in original published article).

^^Abstract.

*poor quality; **fair quality; ***good quality.

The evidence surrounding the geographical diversity of the relationship between sleep and resilience was widespread across different countries. For example, there were 14 studies reported from the United States, 17 from China, nine from Switzerland, seven from Korea, five from Norwegian populations, Iran had three studies, and one each from Turkey, New Zealand, Taiwan, Spain, Canada and Thailand. Four studies did not specify the country where the research had been conducted, however ethical applications for these four studies were approved by institutions in Australia (48), the United Kingdom (51), Belgium/The Netherlands (66) and France (67). Three studies (53, 84, 91) captured and reported data from multiple countries ranging from seven (53) up to 94 (84). The five studies that were excluded from the meta-analysis were conducted in the United States (n=3), Russia (n=1), and China (n=1). Whilst most of the included studies acquired data from the general population, some focused on specific populations including healthcare workers and/or medical students, army and/or spouses, athletes/sportspersons, students (school, college or university), pregnant women, or parents/caregivers of children with health conditions (cancer and autism spectrum disorder). Most of the studies captured by our review employed a cross-sectional design, and 11 articles were prospective, with all, except for one, focusing on sleep quality (55). The duration of longitudinal studies ranged from three days (55) up to nine years (43). Whilst one study employed a longitudinal study design, the statistical analysis used to assess the sleep-resilience relationship was cross-sectional and was therefore included with the other cross-sectional studies for the pooled analysis (39). Most studies reported correlation coefficients for the sleep-resilience relationship, whereas the minority reported more robust statistical analyses where potential confounders had been adjusted. The relationship between sleep and resilience was not the primary focus for many of the articles, rather the authors generally reported this as secondary analyses. A total of 55 studies reported on the relationship between sleep quality and resilience. Four explored sleep duration and eight studies explored both sleep parameters in relation to psychological resilience. The most utilised sleep quality instrument across the studies captured was the Pittsburgh sleep quality index (PSQI; n=35) and the insomnia severity index (ISI; n=16). To assess resilience, the most commonly used tool was the Connor-Davidson resilience scale (CD-RISC; n=31) and the mental toughness questionnaire (MTQ; n=14), or versions of these instruments. It is important to note that, whilst resilience and mental toughness overlap and are similar, they are distinct concepts. Both are related to efficiently conquering and coping with stressful situations (104). However, mental toughness is usually linked to positive circumstances. Conversely, resilience usually applies to negative contexts (104), thus it is important to acknowledge these modest differences within our review. In terms of quality assessment, of the 68 articles, 43 were deemed to be good quality, 15 were fair, and 10 were poor.

The results of all studies included in the meta-analysis showed that the pooled correlation coefficient for the relationship between sleep duration and sleep quality with psychological resilience was r=0.11 (95% CI: 0.04-0.17; Figure 2) and r=0.27 (95% CI: 0.20-0.34; Figure 3), respectively. The pooled correlation coefficient remained similar, although slightly attenuated, when the analysis was repeated for longitudinal studies that assessed the relationship between sleep quality and resilience, where r=0.18 (95% CI: 0.07-0.29; Figure 4). There were an insufficient number of studies that prospectively examined sleep duration and resilience to conduct a pooled analysis. There was evidence of high heterogeneity for the studies in our meta-analysis, as indicated by the I^2 values in Figures 2 (I^2=89.4%, $p<0.001$), 3 (I^2=98.6%, $p<0.001$) & 4 (I^2=92.6%, $p<0.001$).

INSERT FIGURE 2 HERE

Figure 2: Forest plot for all included studies that explored the relationship between sleep duration and psychological resilience.

INSERT FIGURE 3 HERE

Figure 3: Forest plot for all included studies that explored the relationship between sleep quality and psychological resilience

INSERT FIGURE 4 HERE

Figure 4: Forest plot for all included studies that explored the prospective relationship between sleep quality and psychological resilience

There was also evidence of publication bias, as revealed by the funnel plot presented for studies that explored the relationship between sleep quality and resilience (Figure 5). There were fewer studies that examined the association between sleep duration and psychological resilience and evidence of publication bias for these were more limited (see Figure 6).

INSERT FIGURE 5 HERE

Figure 5: Funnel plot for included studies that assessed the relationship between sleep quality and psychological resilience

INSERT FIGURE 6 HERE

Figure 6: Funnel plot for included studies that assessed the relationship between sleep duration and psychological resilience

Discussion

The results of our meta-analysis demonstrate a clear positive, relationship between sleep (quality and quantity) and psychological resilience. Given that our review presents pooled correlational estimates, causation cannot be assumed. Nonetheless, it is useful to consider and speculate on possible explanations for the observed relationship. Our pooled analysis suggest that longer sleep duration and better sleep quality are related to higher levels of resilience with the strongest effect observed for sleep quality. These observations make intuitive sense given the copious amounts of robust research that evidence a plethora of negative health and performance outcomes in relation to short sleep duration, and to a lesser extent, poor sleep quality (1-5). Whilst the correlational study designs prevent us from drawing temporal associations, the prospective studies captured from our searches do seem to suggest a causal relationship, therefore it is useful to speculate on potential mechanistic explanations.

First, individuals that acquire a sufficient amount of sleep which is also of good quality are more likely to be absent of chronic disease, have better hormone regulation (3) and may also be better cognitively equipped to cope with stressors. Thus, those with good sleep habits, who are healthy and better prepared to tackle lives challenges, will likely be more resilient to stressors by adopting adaptive coping strategies. At least one study captured in our review supports this notion in that better sleep quality is associated with higher levels of resilience (69). The authors considered resilience as the dependent variable and found that lower global sleep quality score on the PSQI was associated with significantly higher scores on resilience amongst a large sample of college students (69). Previously, it has been noted that slow wave sleep (SWS) is associated with multiple physiological homeostatic processes including decreases to blood pressure, heart rate, cerebral glucose utilization, as well as sympathetic nervous system activity (3). These observations are, in part, likely to be due to the inhibition of cortisol, a key stress hormone, during SWS, as compared to wakefulness. Thus, if healthy sleep habits regulate and maintain cortisol homeostasis then individuals may be able to better cope with stressors and develop higher levels of resilience. In line with this notion are findings from a cross-sectional study of nurses who were categorized into high versus low sleep quality groups based on the PSQI global score. The nurses completed a sustained attention task online and provided four diurnal saliva samples for assessment of cortisol levels. Those with low sleep quality had significantly earlier wake times, possibly suggesting shorter sleep duration and/or poorer sleep quality, lower cortisol awakening and morning-to-evening responses, and reaction time was longer on the psychomotor vigilance task, as compared to the high sleep quality group (105). Thus, sleep quality appears to influence cortisol levels as well as cognitive responses, which in turn, may determine how an individual responds to, and copes with, stressful situations. Interventions that have targeted improving sleep behavior have also been linked to improved mental health and quality of life outcomes, as well as a reduction in maladaptive stress coping behaviors (106).

Second, individuals with high levels of resilience may have better sleep habits compared to those who are less resilient. For example, highly resilient people may be better equipped with adaptive coping strategies and potentially manage daily challenges without it interfering with their psychological state. It is possible that highly resilient individuals may not ruminate over all possible outcomes of stressors they are presented with. The relationship between rumination and resilience has been recently examined amongst college students during the COVID-19 pandemic revealing that these two concepts are not only closely connected to each other but also to psychological health (107). Less rumination at night-time will undoubtedly result in positive downstream sleep outcomes including shorter sleep onset latency (108), more condensed sleep and ultimately longer sleep duration, compared to those who spend time ruminating over all possible outcomes to stressors they are presented with. Indeed, this notion is what the study by Lui and colleagues seems to suggest (76). They considered sleep disturbance as the dependent variable and resilience as the predictor variable in a series of logistic regression models (76). After adjustment for a range of potential confounders, each one-unit increase on the resilience measure significantly reduced the odds of subjective sleep disturbance by 8% amongst a large sample of community-dwelling adults. The same study suggested that high levels of resilience can off-set the negative consequences of perceived stress on sleep quality (76). Another study captured in our review found a greater effect size for resilience as a protective factor for sleep quality (93). We should also consider a converse explanation for our observation. For example, compared to highly resilient individuals, it is possible that those with low levels of resilience may be more likely to engage in maladaptive sleep behaviors, which would unquestionably result in poorer sleep outcomes such as reduced sleep quantity as well as worse sleep quality indicators such as delayed sleep onset latency, higher levels of wake after sleep onset, increased night-time awakenings and poorer overall sleep efficiency. This notion does, however, need to be verified through focused research studies.

Ironically, exposure to daily challenges, as well as stressors encountered across the lifespan, are a requirement for development of psychological resilience. Thus, it is important to note that timing of when research studies are conducted, as well as the age of participants and the number of stressful life events experienced by individuals are all important factors which could influence the overall findings. The focus of future systematic reviews in this area could specifically focus on populations who have experienced trauma and extreme stress including victims of abuse, natural disasters, and wars to assess the precise role of resilience development and the immediate and long-term impact these have upon sleep outcomes.

Whilst our work is the first systematic review and meta-analyses to explore the association between sleep and resilience, we acknowledge some limitations of our work, as follows. First, as previously stated, correlation is not causation. Good sleep patterns and behaviors may strengthen resilience but equally those who have higher levels of resilience may also be likely to sleep better for the reasons we have discussed. Correlations also lack the control of important confounding factors that could interfere with the overall association. Second, whilst most studies captured in our review were deemed to be good quality (n=43), a small number (n=10) were considered poor quality. Additional studies are therefore still needed to confirm or refute the association between sleep and psychological resilience. Moreover, the primary focus of such future studies should be to explore the direct relationship between these two variables rather than secondary exploratory analyses. Third, most measures of sleep were subjective and whilst these are undoubtedly important, they are also subject to several biases including recall, social desirability and more. Fourth, we limited our inclusion criteria to healthy, general population samples given that clinical samples are likely to carry additional psychological challenges which could have confounded the overall results, particularly given the close connection sleep and resilience have with psychological health. That said, our review captured a range of age groups, demonstrating age diversity, although the majority of studies included adult populations. Finally, we did not include experimental studies, although changes to levels of psychological resilience through sleep manipulation are likely to be observed over extended periods of time rather than in short, experimental, laboratory-based studies. Conversely, exposure to stress-evoking scenarios to assess the effect on sleep outcomes could be ethically inappropriate, depending on the type of stressor presented.

Conclusions

Overall, our systematic review and meta-analysis provides initial evidence of an association between two sleep parameters and levels of psychological resilience. Although our review captured many articles, the primary objective of the majority of studies was not to specifically explore the relationship between sleep quantity/quality and psychological resilience. Thus, future studies could be carefully designed to target a deeper understanding of the sleep-resilience relationship. Additionally, longitudinal studies should be employed, and data should also be obtained on potential confounding factors, to determine robust temporal associations. Given that sleep is not a static behavior, estimates across multiple time points would be necessary to provide a comprehensive understanding. Whilst subjective sleep measures are valuable, a combination of subjective and objective sleep estimates is preferable. In the meantime, continuing to raise awareness and educate the general population about the importance of sleep, particularly in a challenging global pandemic era when resilience is being tested, is likely to promote better overall health and wellbeing.

Practice points

1. Our systematic review explored the association between sleep duration and sleep quality with psychological resilience amongst 131,820 health adults and children. A total of 68 articles met our pre-defined inclusion criteria and 63 were included for meta-analysis.
2. Pooled results indicated a positive correlation between sleep duration and resilience ($r=0.11$, $p<0.001$), as well as sleep quality ($r=0.27$, $p<0.001$).
3. The pooled correlation was slightly attenuated for prospective studies pertaining to sleep quality and resilience ($r=0.18$, $p<0.001$).
4. There was evidence of high levels of heterogeneity across the studies captured as well as publication bias, particularly for articles that focused on sleep quality and resilience.
5. Adopting good sleep habits/patterns may contribute to strengthening resilience-related skills although this needs to be confirmed by a series of long-term prospective and experimental studies.

Research agenda

1. Whilst many studies were captured by our review, assessment of the sleep-resilience relationship was reported as secondary analysis rather than the primary objective of the study. We therefore recommend future studies be carefully designed to better understand the direct association between sleep and resilience.

2. Future prospective studies should acquire data across multiple time points for sleep, which is not a static behavior, and should also obtain a combination of subjective and objective measures to develop a comprehensive understanding.
3. Our review focused on sleep quality and sleep duration but as sleep is multi-dimensional, we encourage researchers to procure collective information on a range of sleep parameters including sleep-wake timings, sleep-wake variability, and circadian preference so that these can each be explored in relation to psychological resilience.
4. We focused on healthy adults and children in our review. We recommend that future studies ascertain and report findings from specific populations such as clinical (patients), those who have suffered extreme hardship and/or victims of abuse.
5. We observed high levels of publication bias detected, therefore we recommend researchers attempt to publish all results, regardless of possible null findings.

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