# Title: Non-Pharmacological Interventions to Lengthen Sleep Duration in Healthy Children

# A Systematic Review and Meta-Analysis

## Sub-title: Interventions to Lengthen Sleep Duration in Healthy Children

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Date of revision: 8th June 2022

Word count: Abstract 317 words, manuscript (text only) 3250 words

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## Key Points

**QUESTION** Are non-pharmacological interventions effective in lengthening sleep duration in healthy children? If so, what are the key elements?

**FINDINGS** In this systematic review and meta-analysis of 45 trials, interventions to improve sleep in healthy children were associated with a small increase in sleep duration (by 10 minutes per night). Face-to-face delivery was an important component of interventions, but interventions that included earlier bedtimes were associated with a substantial 47 minutes longer sleep duration per night.

**MEANING** Supporting children to go to bed earlier can increase sleep duration in healthy children, and interventions to encourage earlier bedtimes should be included.

## Abstract

**IMPORTANCE** Adequate sleep duration is necessary for many aspects of child health, development and wellbeing yet sleep durations for children are declining, and effective strategies to increase sleep in healthy children remain to be elucidated.

**OBJECTIVE** To determine whether non-pharmaceutical interventions to improve sleep duration in healthy children are effective, and to identify the key components of these interventions.

**DATA SOURCES** CENTRAL, MEDLINE, Embase, PsycINFO, Web of Science Core collection, ClinicalTrials.gov, and WHO trials databases were searched from inception to 15th November 2021.

**STUDY SELECTION** Randomised controlled trials of interventions to improve sleep duration in healthy children were independently screened by 2 researchers. A total of 28,478 studies were identified.

**DATA EXTRACTION AND SYNTHESIS** Data were processed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA). Random effects meta-analytic models were used to estimate pooled effect sizes.

**MAIN OUTCOME AND MEASURE** The outcome was difference in sleep duration measured in minutes.

**RESULTS** Pooled results indicate that sleep interventions (45 trials, n=13,539) were associated with 10.5 minutes (95%CI, 5.6 to 15.4) longer nocturnal sleep. There was substantial variation between trials. Sources of variation that were not associated with the study effect size included age group, whether the population was identified as having a sleep problem or being disadvantaged, method of assessment of sleep duration (objective versus subjective), location of intervention delivery (home versus school), whether interventions were delivered in person, used parental involvement, behavioural theory, environmental change, or had greater or lower intensity. Interventions that included earlier bedtimes were associated with a 47-minute sleep extension (3 trials, 95%CI 18.9 to 75.0), compared with remaining studies (42 trials, 7.4 minutes 95%CI 2.9 to 11.8; p=0.006 for group difference). Trials of shorter duration (≤6 month) had larger effects.

**CONCLUSIONS AND RELEVANCE** Interventions focussed on earlier bedtimes may offer a simple, pragmatic, effective way to meaningfully increase sleep duration that could have important benefits for child health.

## Introduction

Early childhood experiences and development can have a significant impact on subsequent health, and adequate sleep during childhood is a critical component of wellbeing. Healthy sleep involves a combination of appropriate sleep timing, quality and duration[1,2]. Sleep in children is vital for appropriate growth, cognitive processing, mental wellbeing, effective social interactions and metabolic health[3-6].

Marked differences in sleep patterns are observed through childhood, with declines in sleep duration with increasing age. Guidance from the US National Sleep Foundation recommends that toddlers aged 1-2 years should sleep 11 to 14 hours per night, pre-school aged children 3-5 years 10 to 13 hours, school aged children 6-13 years 9 to 11 hours, and teenagers 14-17 years 8 to 10 hours,[1] with similar decreasing sleep durations with increasing child age in the UK,[7] reflecting the changes in circadian rhythm and sleep homeostatic sleep processes during child development. While these recommendations are not derived from systematic reviews and meta-analysis of the evidence, they represent the best available consensus from a multidisciplinary expert panel.[1] Unfortunately, fewer children are achieving these recommendations, with a trend towards shorter sleep durations,[8-11] where currently a third or less of younger children and adolescents are achieving adequate sleep durations.[8-10] These short sleep durations have been attributed to increased screen time, electronic media use, stimulant intake (particularly caffeine)[12-19], and increasing emergence of unhealthy sleep behaviours, including poor bedtime routines (such as irregular sleep timings and unsupportive environments) [20,21].

Effective strategies are therefore needed to encourage healthy sleep and optimize sleep behaviour in children. Recent systematic reviews and meta-analyses largely of intervention studies have focussed on those with sleep problems and/or medical issues[22-24], restricted to narrow age groups[21,25-28] including infants and pre-schoolers where circadian sleep patterns are not yet fully established[26-28], have also considered suboptimal non-experimental studies[26], and have lacked sufficient evidence to unravel the role of single component versus multi-component interventions as part of broader health improvement agendas[21]. Most reviews to date have also been narrative, which may reflect a lack of standardization in reporting sleep-related outcomes, particularly sleep duration[25]. Of the few meta-analyses that have quantified overall intervention effects, pooled estimates have been modest at best[26].

Increasingly, objective measurements are being used, which limits comparisons with previously reported self- or parentally-reported sleep[26].

Interventions in school-aged children may offer an ideal age group to alter nocturnal sleep behaviour, given circadian sleep patterns are well established, and scope to deliver interventions within both school and home settings. Hence, we have carried out an up-to-date systematic review of intervention studies to promote optimal sleep patterns in all children, including those of school age (aged 1 to 18 years).

## Aim

The main aim of this systematic review and meta-analysis was to estimate the effectiveness of sleep-related interventions in healthy children. Secondary aims included subgroup exploration to identify which sleep-related intervention components are most or least effective, and to estimate the effect size of these different elements.

## Methods

This systematic review and meta-analysis was reported according to PRISMA guidelines[29], aligned with the EQUATOR reporting guidelines. The protocol was registered on the international prospective register of systematic reviews (PROSPERO registration CRD42019160089).

### Eligibility Criteria

Eligible studies were both individual and cluster RCTs (at both class and school level) investigating interventions to affect sleep duration in children, aged between 1-18 years, without a known medical condition or disability. Studies were excluded if they included: infants under 1 year of age, those with a formal diagnosis of a sleep disorder or use of pharmacological interventions. Pharmacological interventions are not recommended first-line for sleep improvement and differ from behavioural interventions[30].

The sleep-related intervention would be stand-alone or part of a multicomponent health promotion strategy, e.g., addressing obesity. The comparator group would be delayed intervention, alternative child health or safety advice, or usual care. The primary outcome was change in mean self-reported, parental-reported, or objectively measured daily total sleep-time (in minutes) in children receiving the intervention compared with controls. Non-English language studies were excluded at the full-text screening stage.

Additional proposed outcomes were change in measures of sleep quality (based on study specific subjective scales) and sleep hygiene (based on study specific sleep hygiene scales). However, due to the heterogeneity of these measures and lack of consistency between studies, it was not possible to meaningfully synthesise these outcomes.

## Search Strategy

We carried out searches using both text words and MeSH/index terms in 7 databases: CENTRAL, MEDLINE (Ovid), Embase (Ovid), PsycINFO (Ovid), Web of Science Core Collection, ClinicalTrials.gov, and WHO trials databases. Searches were carried out from database inception to 15th November 2021. The search strategy used is provided in eTable 1.

We used the Cochrane RCT Classifier[31] for an initial assessment of the results. Following this, all remaining titles and abstracts were screened independently by two reviewers using Covidence version 1.0[32], with discrepancies resolved by a third reviewer. Full text screening was carried out independently by two reviewers in the research group and disagreements were resolved with a third reviewer.

## Data Extraction

Study information was extracted using the Covidence data extraction form, edited to include relevant fields specific to this review, including details about the study population, intervention design and delivery. Use of theory in the interventions was assessed using a framework[33] which has been utilised in previous systematic reviews[34,35], assessed against 4 levels: informed by theory, applied theory, testing theory and building theory. Data were extracted by two reviewers independently with discrepancies discussed and resolved with a third reviewer (LM,AD,CW), as necessary.

Quantitative data were extracted using a structured data extraction sheet in Microsoft Excel. The data extraction sheet was piloted on 6 trials by (UC) and (CO). Extraction included data in different forms (e.g., means at end-point or change-on-change), using different measurement methods (e.g. actigraphy or self-/parental-report) related to sleep at different times of the week (e.g., weekend or weekday) and at different follow-up periods. Quantitative data extraction was undertaken independently by two reviewers with discrepancies discussed and resolved with a third reviewer where necessary (UC,LG,AR). Due to reporting inconsistency of intervention length and follow-up period, these were combined under study period.

## Study Quality

Cochrane's 'Risk of Bias' tool[36] was chosen over alternative instruments as it is sensitive to variation in the quality of randomised controlled trials. Two reviewers independently scored the domains (selection bias, performance bias, detection bias, attrition bias, reporting bias, and other biases) prior to data analysis, with discrepancies resolved by a third reviewer (LM,CW,AD).

## Data Analysis

We used Cochrane's Review Manager (version 5.4)[37] to calculate effect estimates (in minutes) and associated 95% confidence intervals (CI), using a random effects mean difference model. Trials were excluded if the number of participants at follow up could not be established. The comparator group was split to avoid double counting in three-arm trials, and where a study did not report pooled results for the entire sample, effects reported were combined using a fixed effects meta-analysis. Adjusted effect estimates were preferred over unadjusted estimates, and the longest follow-up period was selected for inclusion where multiple follow-up periods were reported. Data for weekday sleep were used in preference to weekend sleep.

Further analyses were performed in STATA version 17 (using *metan* and *metareg* commands)[38]. Subgroup analyses, examining differences in effect estimates for different populations (e.g., by age group, continent, level of disadvantage, self-identified sleep problem), and study design features (e.g., method of measuring of sleep duration, length of intervention, location and mode of delivery) were performed (using Z-tests). Statistical heterogeneity was assessed using the $I^2$ statistic, and p-values. An $I^2$ value of 50-75% suggested moderate heterogeneity, and 75% or above high heterogeneity [39]. We assessed publication bias by visual examination of funnel plots, and using Begg and Egger tests, overall and by subgroups.

# Results

A total of 28,478 studies were identified, of which 8,854 were duplicates. The RCT classifier excluded 5,460 records and a further 436 duplicates were identified resulting in 13,728 studies to be screened. After screening of titles and abstracts, 411 potentially relevant full-text articles were screened. Figure 1 shows the article selection process. In total, 45 RCTs with 47 estimates of mean differences in sleep duration between intervention and control groups were included in the analyses (with 13,539 child participants, mean age range 18 months to 19 years; 6,897 in the intervention group, 6,642 controls). The key characteristics of selected trials and interventions are shown in Table 1 (more detailed characteristics in eTable 2, study estimates in eTable 3). Of 45 trials, 10 were in pre-school age, 11 primary school age and 26 in secondary school age.

The primary analysis found that sleep interventions were associated with 10.5 minutes (95% CI 5.6 to 15.4 mins, p<0.0001) longer nocturnal sleep duration compared with the control condition. Figure 2 shows the primary meta-analysis forest plot, with quality assessments. There was marked heterogeneity across study estimates ($I^2$=87.2%). All subgroup comparisons, by population characteristics, study design features and intervention features are summarised in Table 2.

## Differences in sleep duration by study population characteristics

There were no significant differences in sleep duration estimates across different pre-school, primary and secondary school age groups, presence of social disadvantage, or whether the study population included those reporting sleep problems. Most trials were carried out in high income countries in children of largely white European ancestry (i.e., 15 trials were carried out in North America, 12 trials Australasia, 9 in Europe); the remaining trials were carried out in Asia (7 trials) and South America (4 trials). There were significant differences in the effect size estimates by study geography (p=0.015); pooled estimates from North American and Asian trials appeared to show the largest difference in sleep duration , 15.6, 95%CI 3.8 to 27.5 mins and 16.9 95% CI 4.5 to 29.4 respectively), compared with pooled trials from Australasia and South America that showed no change (-0.6, 95% CI -5.8 to 4.7 and 5.0, 95% CI -1.2 to 11.0 mins, Table 2) with wide confidence intervals.

## Differences in sleep duration by study design features

There were no overall differences in sleep duration when measured using objective (accelerometer or electroencephalography) vs subjective (sleep diaries, child or parental report) methods. However, there were considerable differences in sleep duration among the trials relying on subjective reports (p<0.001), where those using parental-report were associated with a very small change in sleep (0.4, 95%CI -3.4 to 4.3 mins), those relying on child report were associated with a non-significant difference in sleep duration (7.8, 95%CI -2.3 to 17.7 mins), whereas trials using sleep diaries were associated with a large difference in sleep duration (26.4, 95% CI 17.7 to 35.2). Estimates from trials recording data on 7 nights per week (all week nights) were similar to those recording data 5 nights per week (weekday nights); 11.9 minutes (95%CI 4.0 to 19.7) vs 10.3 minutes (95%CI 2.5 to 18.2), respectively. Two trials only reported data for weekend nights, reporting a lower effect estimate (2.9, 95%CI -0.1 to 5.8); the difference between subgroups was significant (p=0.035). Trials that reported final follow-up data within 6 months of the baseline reported significantly greater effect sizes than those reporting final follow-up beyond 6 months.

## Differences in sleep duration by intervention features

There were no statistically significant differences in sleep duration estimates by the location of intervention delivery (e.g., home or school), with parental involvement in the intervention, or in whether the intervention was delivered face-to-face. Trials which focussed on lengthening sleep alone showed significantly more change in sleep duration (15.8, 95%CI 8.9 to 22.6 minutes) than interventions with broader aims (1.2, 95%CI -2.5 to 5.0 minutes; p<0.0001). There were no statistically significant differences in the effects of trials by intensity of intervention delivery, use of environmental change to support longer sleep, or whether behavioural theory was used to inform intervention design.

Trials which focussed on obesity had a smaller effect; 3.3 minutes, (95%CI -4.8 to 11.3), compared with other trials 12.8 minutes, (95%CI 7.0 to 18.7); (p=0.06). Similarly, trials with a physical activity component had a significantly smaller effect size compared with those with no physical activity component; 1.6 minutes (95%CI -1.2 to 4.5) vs 13.4 minutes (95%CI 7.1 to 19.6), respectively (p=0.001). Trials which involved an earlier bedtime had a significant and substantially greater effect estimate (47.0 minutes, 95%CI 18.9 to 75) compared with the effect of trials which did not encourage participants to go to bed earlier (7.4 minutes, 95% CI 2.9 to 11.8; p=0.006). The effect of early bedtimes was in fewer studies (3 trials), but the effect appeared similar in studies carried out in primary school aged children, and 2 studies solely in secondary school aged children (p=0.15).

Heterogeneity in subgroup analyses varied between 0% and 95.5%.

## Possible effect of bias and other factors on differences in estimates of sleep duration

Visual inspection did not reveal any clear pattern of small study / publication bias overall (Egger test=0.85); There was no clear pattern of small study bias by sub-groups. Equally, risk of bias assessments, including selection bias, performance bias, detection bias, attrition bias, reporting bias, and other biases (shown in Figure 2), did not provide notable patterns in the data. There was no evidence that differences in sleep duration between intervention and control differed by quartile groups of baseline levels of sleep duration (p=0.57). Moreover, there was no evidence of a systematic difference in unadjusted versus adjusted sleep duration analyses, both at a study (n=45) or estimate (n=58) level (p=0.34, 0.48, respectively).

## Discussion

This systematic review found that sleep interventions in children aged 1 to 18 years were associated with 10.5 minutes longer sleep duration per night. Many intervention components have small effects on sleep duration. Substantial increases in sleep duration were observed in a subgroup of trials encouraging earlier bedtimes, with objectively measured sleep durations increasing by 47 minutes. Interventions which have a broader focus (e.g., interventions which focus on obesity) were ineffective in increasing sleep duration, extending sleep by 1.2 minutes, compared with 16 minutes in interventions focussed on sleep only.

The pooled effect estimate of 10.5 minutes longer sleep duration per night is similar to previous reviews which included fewer trials with correspondingly fewer participants[26], or narrower age groups (e.g., infants, or infants and pre-school children only[26-28]). While a recent meta-analysis of older children and young adults (12 to 25 years) found a larger intervention effect (35 mins), the pooled estimate was associated with wide confidence intervals (95% CI 8.70, 61.14) inclusive of our overall finding[40]. Notably, the pooled effect estimate from that review is similar to the estimate reported in the present review for trials that encouraged earlier bed-times, and importantly employed objective actigraphy measurement of sleep duration (with 2 trials being used in both reviews[41,42]), which limits well-known biases associated with self-or parentally-reported sleep times[26]. While prior qualitative reviews have suggested that multi-component interventions, underpinned by behavioural theory might be more effective[25], our findings (in agreement with another previous review[26]) demonstrate that simple sleep-focused interventions are more effective.

We included a large number of RCTs (45 trials with 13,539 participants) which provide the best available evidence of potential intervention. This review spans the entirety of childhood (excluding infants <1 year) and finds no clear evidence of differences in overall intervention effects by age. Most trials included in this review were carried out in primary- and secondary-school aged children, where circadian sleep patterns and nocturnal sleep behaviour are well established. The trials included delivered interventions in both school and home settings, and no difference was found in the effect sizes of interventions in either setting. These findings suggest that reinforcement of interventions in both settings could be used for future implementation. Differences in individual study results were reflected by high levels of heterogeneity in both the main and sub-group analyses.

There were inconsistencies measuring sleep related outcomes across trials. Sleep duration was the most commonly reported outcome, but there was variation in the analytical approach, with some trials reporting mean sleep durations by intervention and control groups, others mean differences in sleep duration between groups at follow-up, or differences-in-differences (with differing levels of adjustment); although, there was no evidence of systematic differences across these groups. Other important sleep-related outcomes beyond duration, such as sleep quality and latency (not reported here), were inconsistently and less frequently reported, which presents challenges for appropriately pooling results. Similarly, other intervention characteristics were not routinely reported and while interventions underpinned by theory did not appear to be associated with longer sleep durations, more detailed reporting of the use of theory (including behavioural models underpinning proposed interventions) and study fidelity (including uptake and compliance with a given intervention) could usefully contribute to the evidence by allowing effective components to be more readily identified, which would support the development of novel interventions.

While an overall 10-minute increase in sleep duration would have a modest effect in addressing declining sleep durations in children[8-11], a 47-minute increase associated with earlier bedtimes would substantially impact on this population-level problem. However, while the difference in sleep duration among trials employing earlier bedtimes was much larger, this was only based on 3 studies (1 trial in primary school aged[43] and 2 trials in secondary school aged children[42,44]), largely for the USA[42,43], and these findings need to be replicated in further studies and settings. If confirmed, earlier bedtimes are needed given wake-up times are less changeable, especially on schooldays. While one randomised controlled trial from Israel included in our review showed 55 minutes longer sleep duration by delaying school start times by 1 hour within the first week, this was not sustained.[45] Further high quality experimental evidence is needed,[46] especially as interventions to shift wake-up times by delaying school start times in a UK context have been shown to be impractical.[47] However, recent observational evidence from the USA has shown that increased sleep duration (by as much as 40 mins) could be achieved by delaying school start times, suggesting that such an approach might be feasible [48,49]. In our study, control group children achieved only 8.6 hours sleep overall, with 10.4 hours in 10 trials of pre-school children, 9.2 hours in 9 trials of primary school-aged children, and as little as 7.6 hours in 22 trials of secondary school-aged children. These durations are much shorter than current recommended levels of 10-11 hours in 4 to 12 year olds, and 8-10 hours in 13 to 18 year olds[1]. Lengthening time asleep by 47-minutes among those with inadequate sleep duration could not only address these shortfalls but could also have important benefits for child health. Observational evidence in 8 to 10-year olds suggests that such increases could have an appreciable impact on cardiometabolic health (e.g., 0.1 $kg/m^2$ lower BMI, and 2% reduction in insulin resistance)[50], as well as having potential benefits for mental health and well-being[6]. Patterning sleep behaviour from early age could also track into adulthood, with potential benefits for health in later life. Currently the only studies encouraging earlier bedtimes within the age ranges of this study were conducted largely in adolescents. Further research is urgently needed to establish whether similarly large effect sizes are observed in sleep interventions encouraging earlier bedtimes in younger children, and, moving beyond this, to establish whether the effects can be sustained. Additional research is also needed to clarify the long-term benefits of such interventions on health outcomes.

## Conclusion

Typically, non-pharmacological interventions increase sleep by a small amount (10.5 minutes). Intervention elements, such as a narrow focus on sleep including earlier bed times should be taken forward in terms of study design to help children achieve adequate sleep to support growth, cognitive development, mental wellbeing and metabolic health. Based on the best available evidence to date, earlier bedtimes offer a simple, pragmatic strategy to meaningfully increase sleep duration.

## Author Contributions

LM was involved in data collection, data interpretation, project administration, preparation of figures for publication, writing the original draft, and ongoing review & editing. LG contributed to data collection, data analysis, statistical analysis, data interpretation, preparation of figures for publication, writing the original draft, and ongoing review & editing. UC contributed to data collection, data analysis, statistical analysis, data interpretation, manuscript writing, review & editing. AD contributed to data collection, data interpretation, manuscript review & editing. CW contributed to, data collection, data interpretation, manuscript review & editing. ES contributed to data searches, manuscript review & editing. CMN contributed to data collection, data interpretation, statistical analysis, manuscript review & editing. AR conceptualized and supervised the study, and led data collection, data interpretation, study design, validation of results, manuscript review & editing. CGO conceptualized and supervised the study, and led data collection, data interpretation, study design, validation of results, writing the original draft, and ongoing review & editing. The corresponding author had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. All authors shared the final responsibility for the decision to submit for publication.

## Declaration of Interests

All authors declare no competing interests.


## Funding/Support Statement

No funding. The sponsor had no role in design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.


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# Figure Legends

**Figure 1: Study selection process**

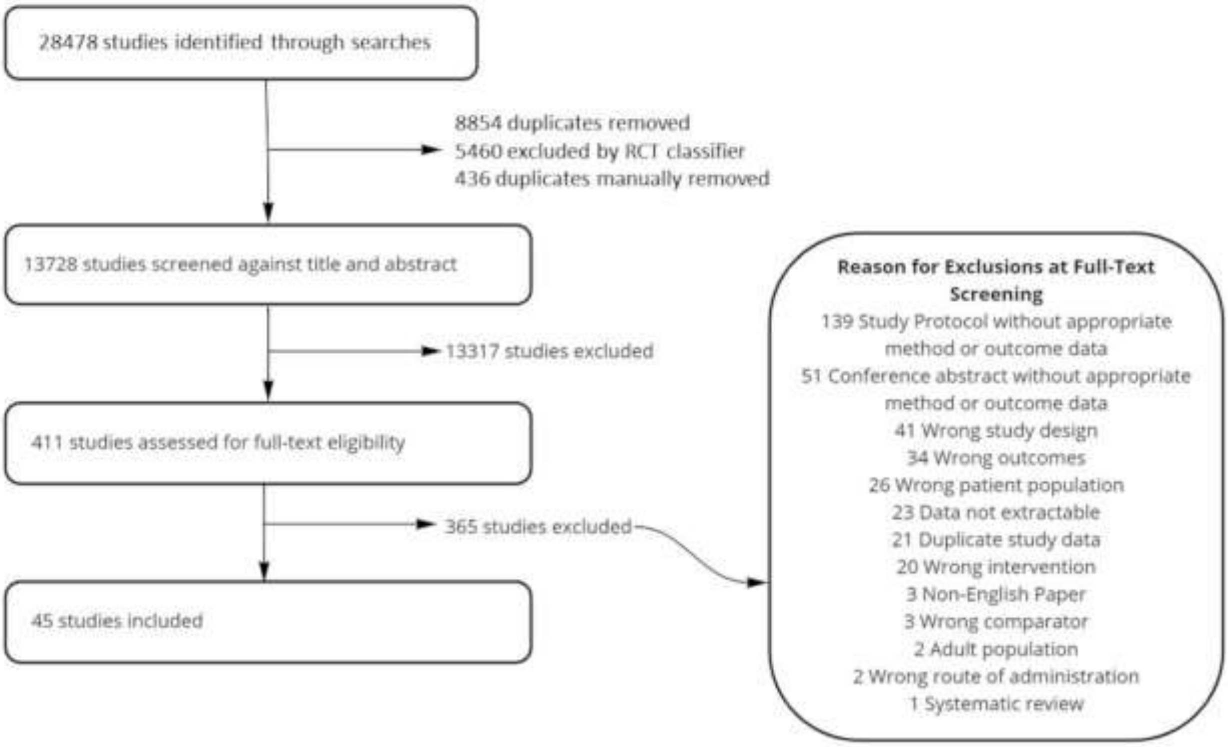
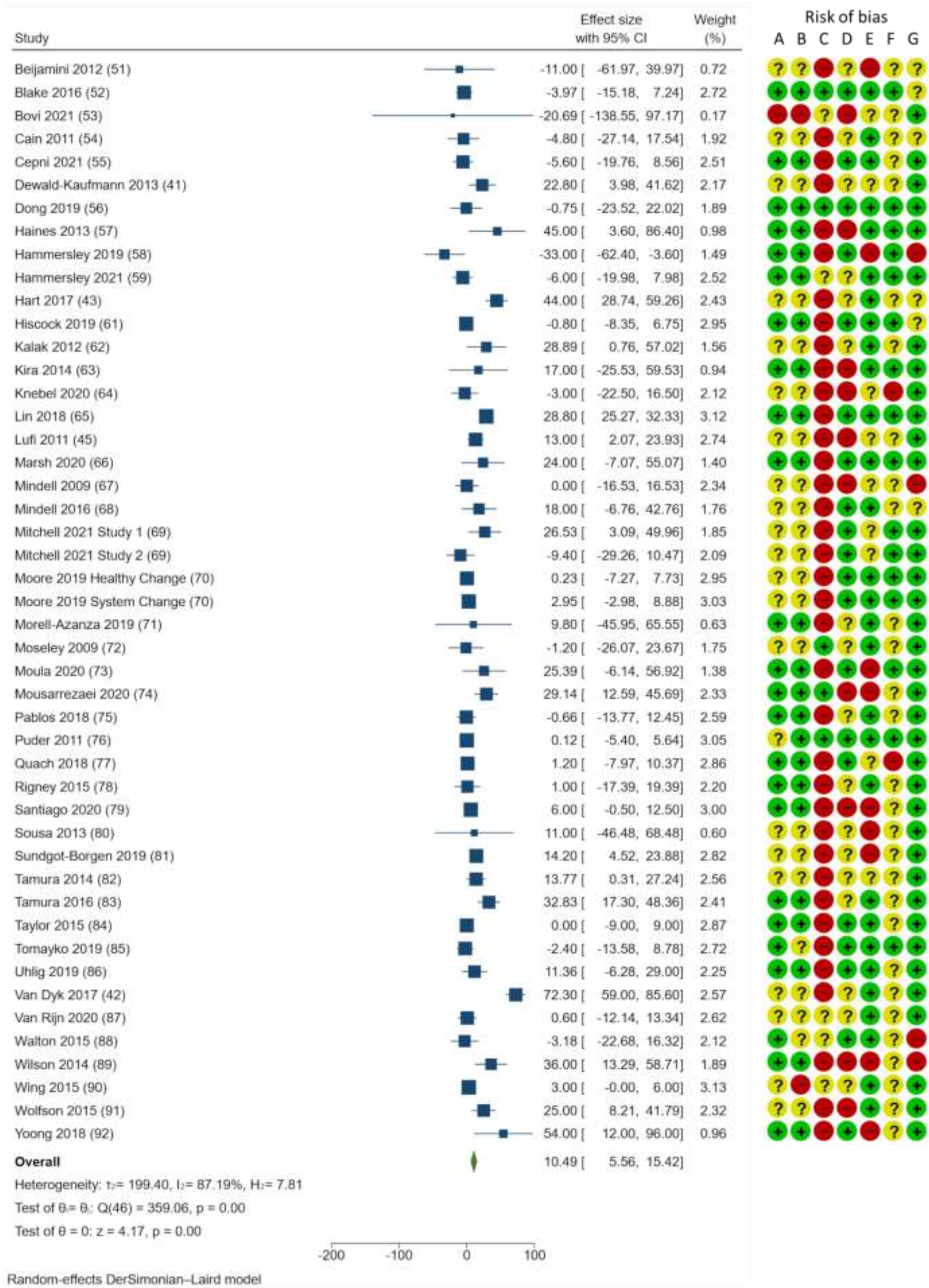


**Figure 2: Forest plot showing mean differences in sleep duration (minutes) in 45 studies, comparing sleep intervention groups with control**


Study
Effect size with 95% CI
Weight (%)
Risk of bias
A B C D E F G
Beijamini 2012 (51) -11.00 [ -61.97, 39.97] 0.72
Blake 2016 (52) -3.97 [ -15.18, 7.24] 2.72
Bovi 2021 (53) -20.69 [ -138.55, 97.17] 0.17
Cain 2011 (54) -4.80 [ -27.14, 17.54] 1.92
Cepni 2021 (55) -5.60 [ -19.76, 8.56] 2.51
Dewald-Kaufmann 2013 (41) 22.80 [ 3.98, 41.62] 2.17
Dong 2019 (56) -0.75 [ -23.52, 22.02] 1.89
Haines 2013 (57) 45.00 [ 3.60, 86.40] 0.98
Hammersley 2019 (58) -33.00 [ -62.40, -3.60] 1.49
Hammersley 2021 (59) -6.00 [ -19.98, 7.98] 2.52
Hart 2017 (43) 44.00 [ 28.74, 59.26] 2.43
Hiscock 2019 (61) -0.80 [ -8.35, 6.75] 2.95
Kalak 2012 (62) 28.89 [ 0.76, 57.02] 1.56
Kira 2014 (63) 17.00 [ -25.53, 59.53] 0.94
Knebel 2020 (64) -3.00 [ -22.50, 16.50] 2.12
Lin 2018 (65) 28.80 [ 25.27, 32.33] 3.12
Lufi 2011 (45) 13.00 [ 2.07, 23.93] 2.74
Marsh 2020 (66) 24.00 [ -7.07, 55.07] 1.40
Mindell 2009 (67) 0.00 [ -16.53, 16.53] 2.34
Mindell 2016 (68) 18.00 [ -6.76, 42.76] 1.76
Mitchell 2021 Study 1 (69) 26.53 [ 3.09, 49.96] 1.85
Mitchell 2021 Study 2 (69) -9.40 [ -29.26, 10.47] 2.09
Moore 2019 Healthy Change (70) 0.23 [ -7.27, 7.73] 2.95
Moore 2019 System Change (70) 2.95 [ -2.98, 8.88] 3.03
Morell-Azanza 2019 (71) 9.80 [ -45.95, 65.55] 0.63
Moseley 2009 (72) -1.20 [ -26.07, 23.67] 1.75
Moula 2020 (73) 25.39 [ -6.14, 56.92] 1.38
Mousarrezaei 2020 (74) 29.14 [ 12.59, 45.69] 2.33
Pablos 2018 (75) -0.66 [ -13.77, 12.45] 2.59
Puder 2011 (76) 0.12 [ -5.40, 5.64] 3.05
Quach 2018 (77) 1.20 [ -7.97, 10.37] 2.86
Rigney 2015 (78) 1.00 [ -17.39, 19.39] 2.20
Santiago 2020 (79) 6.00 [ -0.50, 12.50] 3.00
Sousa 2013 (80) 11.00 [ -46.48, 68.48] 0.60
Sundgot-Borgen 2019 (81) 14.20 [ 4.52, 23.88] 2.82
Tamura 2014 (82) 13.77 [ 0.31, 27.24] 2.56
Tamura 2016 (83) 32.83 [ 17.30, 48.36] 2.41
Taylor 2015 (84) 0.00 [ -9.00, 9.00] 2.87
Tomayko 2019 (85) -2.40 [ -13.58, 8.78] 2.72
Uhlig 2019 (86) 11.36 [ -6.28, 29.00] 2.25
Van Dyk 2017 (42) 72.30 [ 59.00, 85.60] 2.57
Van Rijn 2020 (87) 0.60 [ -12.14, 13.34] 2.62
Walton 2015 (88) -3.18 [ -22.68, 16.32] 2.12
Wilson 2014 (89) 36.00 [ 13.29, 58.71] 1.89
Wing 2015 (90) 3.00 [ -0.00, 6.00] 3.13
Wolfson 2015 (91) 25.00 [ 8.21, 41.79] 2.32
Yoong 2018 (92) 54.00 [ 12.00, 96.00] 0.96
Overall 10.49 [ 5.56, 15.42]
Heterogeneity: τ2 = 199.40, I2 = 87.19%, H2 = 7.81
Test of θi = θj: Q(46) = 359.06, p = 0.00
Test of θ = 0: z = 4.17, p = 0.00
-200 -100 0 100
Random-effects DerSimonian–Laird model

Key: Mean differences in sleep duration (minutes) for each study, comparing duration in those receiving a sleep intervention versus control. Point estimate shown by blue solid squares, with horizontal lines showing the 95% CI. The study authors are indicated on the y-axis in alphabetical order. The pooled estimate based on a random-effects model is shown with a blue diamond (95% CI). Risk of bias legend: (A) Random sequence generation (selection bias), (B) Allocation concealment (selection bias), (C) Blinding of participants and personnel (performance bias), (D) Blinding of outcome assessment (detection bias), (E) Incomplete outcome data (attrition bias), (F) Selective reporting (reporting bias), (G) Other bias. Risk of bias criteria graded from green '+' low risk, yellow '?' unclear, or red '-' high risk.

**Table 1: Study Characteristics**

| Name | Study title | Age range/ mean | Target population | Setting[a] | Inclusion criteria | Mode of delivery | Intervention overview [b,c] | Dose | Intervention duration | Study duration |
|---|---|---|---|---|---|---|---|---|---|---|
| **Beijamini 2012[51]** | Educational Programme for Sleep (EPS) | 13-14 years | School students in Public High schools | School | General population | Face-to-face | Educational programme of 4 themed lessons on sleep [b] | 4x50min lessons, over 5 days | <1week | 3-weeks |
| **Blake 2016[52]** | Study Sense/Sleep Sense | 12-16 years | Students in year 7-10 at risk for major depressive disorder | Secondary schools | High levels of anxiety and sleeping difficulties but without a depressive disorder | Face-to-face | Sleep education programme, including 7 sessions & information book | 7x90min sessions | 7-weeks | 9-weeks |
| **Bovi 2021[53]** | PediaFit | 6-14 years | Obese children | Pediatric Obesity Clinic in University Hospital | BMI >95th percentile for age and sex according to the CDC 2000 growth curves | Face-to-face group sessions and Whatsapp texts | Clinician led groups session - health nutrition/physical activity | Group session with 3 messages a week for 24 weeks<br>Or as above + monthly in presence visits (4 over 6 months) | 24-weeks | 9-months |
| **Cain 2011[54]** | Motivational sleep intervention | 16-17 years | Psychology students | Secondary schools | Students with discrepant weekday-week-end out-of-bed times (>2 h) and insufficient sleep on school nights (<8 h) | Face-to-face | Sleep education classes & motivational interviewing framework [b] | 4x50min sessions | 4-weeks | 6-weeks |
| **Cepni 2021[55]** | Families Understanding Nutrition and Physically Active Lifestyles (FUNPALs) | 12-36 months | Parent–toddler dyads | Home environment | Low-income and ethnically diverse general population | Face-to-face, text reminders | Trained facilitators and health workers delivered health information and positive parenting coaching | 10x90 minute session, weekly | 10-weeks | 12-weeks |
| **Dewald-Kaufmann 2013[41]** | Gradual Sleep extension | 12-19 years | Adolescents with chronic sleep reduction | School + home phone calls | Adolescents with a Chronic Sleep Reduction Questionnaire (CSRQ) score of ≥40 | Face-to-face and telephone | Personal sleep schedule to gradually extend sleep by 10min per night | Daily sleep schedule provided for two weeks | 2-weeks | 3-weeks |

| Name | Study title | Age range/ mean | Target population | Setting[a] | Inclusion criteria | Mode of delivery | Intervention overview [b,c] | Dose | Intervention duration | Study duration |
|---|---|---|---|---|---|---|---|---|---|---|
| **Dong 2020[56]** | Transdiagnostic sleep and circadian intervention for adolescents | 10-18 years | Adolescents with eveningness chronotype | University based clinic | Reported eveningness and 7-day sleep diary with late onset sleep time | Face-to-face | Promoting behaviour change via four cross-cutting modules (functional analysis, goal setting, motivational interviewing, education) | 6 x 50 min sessions, delivered weekly | 6-weeks | 6-months |
| **Haines 2013[57]** | Healthy Habits, Happy Homes | 2-5 years | Ethnic minority and low-income families | Community Health Centres in deprived areas | Low-income and ethnically diverse general population with a television in their room | Face-to-face, phone calls, texts and printed information | Motivational coaching to adopt healthy routines to reduce obesity | 4xhome visits, 4xphone calls, weekly text messages | 24-weeks | 24-weeks |
| **Hammersley 2019[58]** | Time2bHealthy | 2-5 years | Parent-child dyads | Home environment | General population (healthy weight and overweight) | Online | Online modules targeting multiple behaviours including sleep | 6x30min modules to complete over 11 weeks, weekly email reminders | 23-weeks | 24-weeks |
| **Hammersely 2021[59]** | Time for Healthy Habits | 2-6 years | Children aged 2-6 years | Home environment | General population | Telephone and online | Modules targeting multiple behaviours including sleep via telephone calls or online modules | 6x30min telephone calls or 6 online modules | 3-months | 9-months |
| **Hart 2017,[43] (additional detail from[60])** | Behavioural intervention to enhance time in bed | 8-11 years | Children aged 8-11 years | Not stated | General population | Face to face, telephone | Behavioural strategies (e.g., goal setting, stimulus control, positive reinforcement) to increase time in bed by 1.5 hours | 4 sessions over 8 weeks (week 1 60 mins, week 2 30 mins, telephone week 4, week 6) | 8-weeks | 8-weeks |
| **Hiscock 2019[61]** | Sleep well, Be well | 5-6 years | Children with sleep problems in the 1st year of schooling | Primary schools | Parental report of “moderate” or “severe” sleep problems | Face-to-face, follow-up phone call | Nurse led consultation, providing information on good sleep practice and new sleep routine | 1x45min consultation, 10min follow-up phone call, optional 20min consultation | 4-weeks | 52-weeks |
| **Kalak 2012[62]** | Daily running intervention | 17-19 years | School students | Secondary school | General population | Face-to-face | Daily morning run at school in small groups | 30min run weekdays for 3 weeks | 3-weeks | 3-weeks |
| **Kira 2014[63]** | ACES; adaptation of the Australian Centre for Education in Sleep programme | 13-16 years | School students | Secondary school | General population | Face-to-face plus workbook | A sleep educational programme, including small group discussions [b] | 4x50min sessions | 4-weeks | 10-weeks |
| **Knebel 2020[64]** | Movimente programme | 11-15 years | School students | Secondary school | General population | Face-to-face | Programme to increase physical activity and reduce sedentary time teacher training, environmental improvements, and health education [c] | Structures created and equipment provided to encourage physical activity and teachers encouraged to use | 39-weeks | 39-weeks |

| Name | Study title | Age range/ mean | Target population | Setting[a] | Inclusion criteria | Mode of delivery | Intervention overview [b,c] | Dose | Intervention duration | Study duration |
|---|---|---|---|---|---|---|---|---|---|---|
| **Lin 2018[65]** | A theory-based sleep hygiene intervention | 15years | School students | Secondary school | General population | Face-to-face | A sleep education programme, encouraging behaviour change with individual plan and parental involvement | 4x1hr sessions every two weeks | 8-weeks | 24-weeks |
| **Lufi 2011[45]** | Delayed school start time intervention | 13-14 years | School students | Secondary school | General population | Restructure environment | School start time delayed for one hour [b] | Daily for one week | 1-week | 2-weeks |
| **Marsh 2020[66]** | 3 Pillars Study | 2-4 years | Parent – child dyads | Clinical and home | Children whose daily screen use exceeded recommendations (≥1 hour per day) | Face-to-face and online | Workshop and online materials aimed to promote positive parent-child interactions at bedtime, mealtimes, and when restricting screen time | A half-day workshop and subsequent access to the study website over a 6-week period | 6-weeks | 12-weeks |
| **Mindell 2009[67]** | Bedtime routine intervention | 18-36 months | Mother-child dyads | Home | Mother reported "small" to "severe" sleep problem, but not a sleep disorder | Face-to-face | A nightly 3-step bedtime routine (bath, massage, quiet activities), lights out within 30 mins of end of bath | Everyday | 2-weeks | 3-weeks |
| **Mindell 2016[68]** | Sleep Well! Sleep Hygiene Education | 2-12 years | Socioeconomically disadvantaged children | Home | Children from low income household, without proper bedding | Face-to-face and restructured environment | Sleep education messages for parents | Messages provided twice: week 1 & week 4 | 4-weeks | 4-weeks |
| **Mitchell 2021[69]** | Mobile platform to promote sleep | 10-12 years | Children aged 10-12 years | Home | Parent/guardian report of typically 8–9 hours in bed | Online | Mobile health platform used to send goal achievement messages around bedtimes | Daily messages over a 7 week period | 7-weeks | 9 weeks |
| **Moore 2019[70]** | Healthy Change and Systems Change | 11-12 years | Low-income, minority race, overweight or obese children | Middle school | Children with BMI ≥85th percentile, entering 6th grade | Face-to-Face and telephone | 2 active arms: Healthy Change: behavioural strategies used in CBT and motivational interviewing. System Change: emphasis on restructuring family daily routines | 25 face-to-face (f-t-f) sessions in Year 1, alternating monthly f-t-f and phone sessions year 2, 4 f-t-f sessions and 8 phone sessions in year 3 | 156-weeks | 3 years (annual data collection) |
| **Morell-Azanza 2019[71]** | IGENOI (Intervention Grupo Estudio Navarro de Obesidad Infantil) study | 7-16 years | Children with abdominal obesity | Clinical | Waist circumference above 90th percentile, according to national data | Face-to-face | Family based lifestyle programme. Education sessions around diet | 6 x 30-min sessions | 8-weeks | 8-weeks |

| Name | Study title | Age range/ mean | Target population | Setting[a] | Inclusion criteria | Mode of delivery | Intervention overview [b,c] | Dose | Intervention duration | Study duration |
|---|---|---|---|---|---|---|---|---|---|---|
| **Moseley 2009**[72] | Improving Adolescent Well-Being: Day and Night | 15.6 years | Year 11, psychology class students with delayed sleep | Secondary school | Adolescents with discrepant out of bedtimes (school v weekend mornings >2 h), and insufficient sleep on school nights | Face-to-face | Education sessions promoting and maintaining a healthy lifestyle using a cognitive-behaviour therapy framework [b] | 4 x 50-min sessions | 4-weeks | 6-weeks |
| **Moula 2020**[73] | Arts therapies intervention study | 7-10 years | Primary school children | Primary school | Children with mild emotional and behavioral difficulties | Fact-to-face | Art therapies | 1 hour per week for 8 weeks | 8-weeks | 8-weeks |
| **Mousarrezaei 2020**[74] | Education through Short Message Service | 7-12 years | Mother – child dyads | Home | Children with sleep inadequacy based on sleep duration | Mobile phone | Educational messages sent to mothers via phone about sleep | Daily messages for 4 weeks | 4-weeks | 13-weeks |
| **Pablos 2018**[75] | Healthy Habits Program | 11-12 years | Students attending Spanish primary schools in Eastern Valencia | Primary school | General population | Face-to-face | Education sessions around diet, physical activity, sleep and hygiene + a practical physical activity session [b] | Twice weekly sessions lasting 150 mins | 32-weeks | 32-weeks |
| **Puder 2011**[76] | Ballabeina study | 5.1 years | Children at school in high migrant population areas in Switzerland | Pre-school | General population with >40% migrant children | Face-to-face and take home resources and restructured environment | Multidimensional lifestyle intervention, focused on physical activity, nutrition, media use, sleep and adaptation of the built environment of the preschool class [b] | Children: 4 x 45min sessions a week + 22 additional sessions<br>Teachers: x2 workshops<br>Parents: x3 evenings | 42-weeks | 42-weeks |
| **Quach 2018**[77] | Cogmed Working Memory | 6-7 years | Students in the second year (Grade 1) with low working memory | Primary schools | Children with low verbal and/or visuo-spatial working memory scores relative to their peers | Face-to-face | The Cogmed Working Memory Training tasks on temporary storage and manipulation of verbal and/or visuo-spatial information | 20-25 sessions, 25 mins each, over 5-7 weeks | 5-7-weeks | 26-weeks |
| **Rigney 2015**[78] | Australian Centre for Education in Sleep (ACES) | 11-13 years | Students in Year 6/7 from 12 south Australian schools | Secondary schools | General population | Face-to-face and take home resources | Education sessions on sleep physiology and sleep hygiene [c] | 4x weekly lessons then a group project on sleep which students then presented to parents. | 4-weeks | 18-weeks |

| Name | Study title | Age range/ mean | Target population | Setting[a] | Inclusion criteria | Mode of delivery | Intervention overview [b,c] | Dose | Intervention duration | Study duration |
|---|---|---|---|---|---|---|---|---|---|---|
| **Santiago 2020[79]** | Strength training for sleep | 14-19 years | Students aged 14-19 years | Secondary schools | Adolescents reporting poor sleep quality or sleep disturbance, and daytime sleepiness | Face-to-face | Strength training sessions | 55 mins, 3 times a week, for 12-weeks | 12-weeks | 12-weeks |
| **Sousa 2013[80]** | Sleep Education Program (SEP) | 16.8 years | 12th grade students | Secondary schools | General population | Face-to-face | Education programme about physiological and behavioural processes of sleep and healthy lifestyle | 5 x 50-minute classes | <1-week (5 days) | 4-weeks |
| **Sundgot-Borgen 2020[81]** | Healthy Body Image program | 16.8 years | 12th grade students | Secondary schools | General population | Face-to-face | Interactive workshops, with three themes related to body image, social media literacy and lifestyle [c] | 3 x 90-minute interactive workshops | 13-weeks | 52-weeks |
| **Tamura 2014[82]** | Sleep Education programme with self-help | 9-11 years | Children in years 4 to 6 | Elementary schools | General population | Face-to-face | Education session with quiz about sleep habits, then practicing target sleep behaviour for 2 weeks. Monitoring practice [b] | 1x 40 min sessions, then performing sleep behaviour for two weeks | 2-weeks | 2-weeks |
| **Tamura 2016[83]** | Sleep Education with self-help | 12-13 years | Adolescents in grade 7 public junior high schools | Junior high schools | General population | Face to face | Education session, then practicing a target sleep behaviour for 2 weeks. Monitoring [b] | 1x 45 min session, then the sleep behaviour for two weeks | 2-weeks | 2-weeks |
| **Taylor 2015[84]** | Tailored Family Based Obesity Intervention | 6.5 years | Families with children aged 4 to 8 who were overweight and obese | Clinical setting | Children with BMI ≥85th percentile | Face to face, phone calls | Families attended one multidisciplinary session to develop specific goals then met with a mentor | Initial session (1-2 hours). Meet mentor monthly in year 1; three monthly in year 2 | 104-weeks | 104-weeks |
| **Tomayko 2019[85]** | Healthy Children Strong Families | 2-5 years | American Indian parent-child dyads on tribal reservations | Home | General population from American Indian communities | Mail, text reminders, social media | 12 healthy lifestyle lessons (one mailed each month) | 12 lessons (one each month for a year) | 52-weeks | 52-weeks |
| **Uhlig 2019[86]** | Rap & Sing Music Therapy | 8-13 years | Adolescents in eighth grade | Public primary school | General population | Face-to-face | Rap and sing music therapy sessions [b] | 16 sessions, 45 min each, weekly over 4 months | 16-weeks | 16-weeks |
| **Van Dyk 2017[42]** | Sleep Extension | 14-18 years | High school students who sleep 5 to 7 hours on school nights | Home | General population with reduced sleep | Face to face | Increase time in bed on school nights | Increase time in bed by 1.5 hours/ night for two weeks | 5-weeks | 5-weeks |
| **Van Rijn 2020[87]** | Interactive school-based sleep education program | 14.0 years | Eighth grade secondary school students from an all-boys school in Singapore | Secondary school | General population | Face-to-face | Education program about the importance of sleep, barriers to getting enough sleep, and improving their opportunities for sleep [b] | 4 x 1 hour lessons delivered over 5-weeks | 4-weeks | 11-weeks |
| **Walton 2015[88]** | Parents and Tots Together | 2-5 years | Parents of 2-5 year olds attending early years centres | Ontario early years centres | General population | Face to face | Group discussions about weight related topics, sometimes stimulated by videos of vignettes | 9x 120 min weekly group sessions | 9-weeks | 36-weeks |

| Name | Study title | Age range/ mean | Target population | Setting[a] | Inclusion criteria | Mode of delivery | Intervention overview [b,c] | Dose | Intervention duration | Study duration |
|---|---|---|---|---|---|---|---|---|---|---|
| **Wilson 2014[89]** | Sweet Dreamzzz Sleep Education Programme | 4.3 years | Low-income preschool children and their families | Head Start preschools | General population | Face to face | Education sessions for children with a 20 min daily lesson followed by 20 min of related activity [b] | 8x 40 min sessions for children; 1x 45 min presentation for parents. | 2-weeks | 4-weeks |
| **Wing 2015[90]** | Sleep Education Programme for adolescents | 14.86 years | Seventh- to 11th-grade students aged between 12 and 18 years | Secondary schools | General population | Face to face | Didactic teaching with sleep hygiene tips, followed by small group discussions with cases [b] | 1x 60 min town hall seminar, 2x 40-min small workshops, one month apart | 12.2 weeks | 17.2 weeks |
| **Wolfson 2015[91]** | Sleep Smart Program | 12.5 years | Seventh graders and their parents | Public middle schools | General population | Face to face | Didactic information on adolescent sleep and specific strategies for establishing healthy sleep hygiene practices [c] | 8x 40 min sessions over 4 weeks; then 4x booster sessions at two months & twelve months post-intervention | 52-weeks | 12 months (full results at 4 weeks only) |
| **Yoong 2019[92]** | Sleep Intervention targeting physical activity | 3-6 years, | Parents of 3 to 6-year-olds at a convenience sample of childcare centres | Home | General population | Video, phone, text message | Video targeting key behavioural beliefs about sleep practices & a telephone call using motivational interview techniques | 1x 12 min video, 1-3x phone calls 2-4 weeks later, x2 text messages one week after call. | 12-weeks | 12-weeks |

Footnote: [a] Setting includes where participants were recruited and tested and not necessarily where the intervention has taken place. Studies that reported cluster randomisation at class [b] or school level [c]

## Table 2: Results of sub-group comparisons

| Sub-group comparisons | | Number of studies | Pooled estimate for sub-group in minutes (95% CI), minutes | Heterogeneity $I^2$, p | Difference in subgroup estimates, p |
|---|---|---|---|---|---|
| **Combined estimate; no sub-groups** | | 47 | 10.49 (5.56, 15.42), p<0.001 | 87.2%, p<0.001 | - |
| **Population Characteristics** | | | | | |
| Age group | pre-school (>1 to 5) | 10 | 5.73 (-5.81, 17.26), p=0.33 | 69.1%, p=0.001 | p=0.68 |
| | primary school (aged 6 to 11) | 11 | 11.56 (3.34, 19.78), p=0.006 | 77.9%, p<0.001 | |
| | secondary school (>11) | 26 | 11.36 (4.45, 18.27), p=0.001 | 90.5%, p<0.001 | |
| Continent | North America | 15 | 15.63 (3.76, 27.50), p=0.01 | 90.4%, p<0.001 | P=0.015 |
| | Australasia | 12 | -0.56 (-5.82, 4.70), p=0.83 | 28.9%, p=0.16 | |
| | Europe | 9 | 9.97 (2.06, 17.88), p=0.014 | 49.0%, p=0.047 | |
| | Asia | 7 | 16.93 (4.47, 29.38), p=0.008 | 95.5%, p<0.001 | |
| | South America | 4 | 4.96 (-1.15, 11.02), p=0.11 | 0.0%, p=0.76 | |
| Disadvantage | Population reported to be disadvantaged | 6 | 7.90 (-3.28, 19.09), p=0.17 | 69.7%, p=0.006 | p=0.67 |
| | Population not reported to be disadvantaged | 41 | 10.64 (5.23, 16.04), p<0.001 | 87.9%, p<0.001 | |
| Population has a sleep problem | No | 37 | 9.73 (4.46, 15.00), p<0.001 | 85.5%, p<0.001 | p=0.75 |
| | Yes | 10 | 12.26 (-2.20, 26.73), p=0.10 | 91.9%, p=0.097 | |
| **Study design features** | | | | | |
| Measure of sleep duration | Objective (actigraphy, EEG) | 19 | 11.00 (1.42, 20.58), p=0.024 | 88.1%, p<0.001 | p=0.86 |
| | Subjective (child/parental report/sleep diary) | 28 | 9.95 (3.98, 15.91), p=0.001 | 86.9%, p<0.001 | |
| Subjective measures | Child self-report | 11 | 7.76 (-2.31, 17.65), p=0.13 | 92.8%, p<0.001 | p<0.001 |
| | Parental report | 10 | 0.43 (-3.41, 4.27), p=0.83 | 9.3%, p=0.36 | |
| | Sleep diary | 7 | 26.44 (17.69, 35.19), p<0.001 | 13.5%, p=0.33 | |
| Nights used for data collection | Weekend nights | 2 | 2.86 (-0.10, 5.83), p=0.059 | 0.0%, p=0.56 | p=0.035 |
| | Weekday nights | 19 | 10.34 (2.50, 18.19), p=0.010 | 88.1%, p<0.001 | |
| | All week nights | 26 | 11.86 (4.04, 19.68), p=0.003 | 87.2%, p<0.001 | |
| Study period for participants (including intervention length and follow-up) | One month or less | 12 | 15.22 (7.55, 22.89) p<0.001 | 39.6%, p=0.077 | p<0.001 |
| | Longer than a month and up to 6 months | 24 | 14.61 (6.21, 23.01), p=0.001 | 91.6%, p<0.001 | |
| | Longer than six months and up to 12 months | 6 | 1.64 (-4.65, 7.93), p=0.61 | 41.0%, p=0.13 | |
| | Longer than 12 months | 5 | 0.65 (-2.80, 4.10), p=0.71 | 0.0%, p=0.90 | |
| **Intervention features** | | | | | |
| Location of intervention delivery | Home | 13 | 16.42 (-1.21, 34.05), p=0.068 | 89.9%, p<0.001 | p=0.49 |
| | School | 23 | 9.85 (3.50, 16.20), p=0.002 | 88.1%, p<0.001 | |
| | Combination of locations /other/unspecified | 11 | 5.84 (-1.57, 13.25), p = 0.12 | 72.9%, p<0.001 | |
| Mode of delivery | Face-to-face | 31 | 12.86 (6.16, 19.55), p<0.001 | 89.1%, p<0.001 | p=0.046 |
| | Telephone, text message and/or online | 14 | 4.00 (-1.67, 9.59), p=0.17 | 66.9%, p<0.001 | |
| Parental involvement in delivery | No | 19 | 10.61 (5.20, 16.02), p<0.001 | 69.5%, p<0.001 | p=0.96 |
| | Yes | 28 | 10.39 (2.71, 18.09), p<0.001 | 90.5%, p<0.001 | |
| Physical activity component | No | 36 | 13.39 (7.14, 19.64), p<0.001 | 88.7%, p<0.001 | P=0.001 |
| | Yes | 11 | 1.64 (-1.21, 4.49), p=0.26 | 0.0%, p=0.56 | |
| Intervention aims to improve sleep only | No | 18 | 1.25 (-2.54, 5.03), p=0.52 | 30.3%, p=0.11 | P<0.001 |
| | Yes | 29 | 15.76 (8.90, 22.62), p<0.001 | 90.2%, p<0.001 | |
| Intervention focused on obesity | No | 35 | 12.82 (6.97, 18.68), p<0.001 | 88.5%, p<0.001 | p=0.061 |
| | Yes | 12 | 3.29 (-4.78, 11.35), p=0.43 | 73.6%, p<0.001 | |
| Behaviour models used | No | 29 | 11.33 (5.78, 16.88), p<0.001 | 83.8%, p<0.001 | p=0.65 |
| | Yes | 18 | 8.79 (-0.62, 18.19), p=0.067 | 87.8%, p<0.001 | |
| Environmental change | No | 41 | 11.06 (5.55, 16.58), p<0.001 | 88.3%, p<0.001 | p=0.22 |
| | Yes | 6 | 5.34 (-2.01, 12.68), p=0.15 | 36.8%, p=0.16 | |
| Intervention involves an earlier bedtime | No | 44 | 7.37 (2.93, 11.82), p=0.001 | 82.8%, p<0.001 | p=0.006 |
| | Yes | 3 | 46.97 (18.94, 75.00), p=0.001 | 89.6%, p<0.001 | |
| *Earlier bedtime in younger v older children* | primary school (aged 6 to 11) | 1 | 44.00 28.74, 59.26), p<0.001 | | p=0.88 |
| | secondary school (>11) | 2 | 48.01 (-0.48, 96.52), p=0.052 | 94.4%, p=<0.001 | |
| Intensity | Low/unclear | 23 | 11.13 (4.78, 17.48), p=0.001 | 87.9%, p<0.001 | p=0.64 |
| | Medium | 11 | 11.83 (0.74, 22.93), p=0.037 | 77.3%, p<0.001 | |
| | High | 13 | 7.01 (-0.11, 14.12), p=0.054 | 54.4%, p=0.010 | |

Footnote: Blake 2016[52] data was supplemented by Blake 2018[93] data as both report the same study.