Inclusion of Sleep Promotion in Family-Based Interventions To Prevent Childhood Obesity

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Abstract

Sleep promotion in childhood may reduce the risk of obesity, but little is known of its inclusion in family-based interventions. This study examines the proportion and context of family-based interventions to prevent childhood obesity that promote child sleep. We drew on data from a recent systematic review and content analysis of family-based interventions for childhood obesity prevention published between 2008 and 2015, coupled with new data on sleep promotion strategies, designs, and measures. Out of 119 eligible family-based interventions to prevent childhood obesity, 24 (20%) promoted child sleep. In contrast, 106 (89%) interventions targeted diet, 97 (82%) targeted physical activity, and 63 (53%) targeted media use in children. Most interventions that promoted sleep were implemented in clinics (50%) and home-based settings (38%), conducted in the United States (57%), and included children 2–5 years of age (75%). While most interventions utilized a randomized controlled design (70%), only two examined the promotion of sleep independent of other energy-balance behaviors in a separate study arm. Sleep was predominately promoted by educating parents on sleep hygiene (*e.g.*, age-appropriate sleep duration), followed by instructing parents on responsive feeding practices and limiting media use. One intervention promoted sleep by way of physical activity. A large number promoted sleep by way of bedtime routines. Most interventions measured children's sleep by parent report. Results demonstrate that sleep promotion is underrepresented and variable in family-based childhood obesity interventions. While opportunities exist for increasing its integration, researchers should consider harmonizing and being more explicit about their approach to sleep promotion.

Keywords: childhood obesity; family; intervention; review; sleep

Introduction

Childhood obesity has been referred to as a “wicked” problem¹ for the complexity in identifying and addressing its biological, social, and cultural determinants. In 2011–2012, 17% of children 2–19 years of age, in the United States, were obese, a disproportionate number of whom were children from low-income families and families of color.^{2,3} Energy-balance behaviors, including diet, physical activity, and media use, are robust risk factors for childhood obesity⁴ and are malleable to the family environment.⁵ Families influence children's energy-balance behaviors through parenting strategies, such as modeling healthy eating, encouraging physical activity and outdoor play, and limiting media use (*i.e.*, screen time).⁶ As such, families are commonly designated as the agents of change in childhood obesity interventions.⁷

While diet, physical activity, and media use have traditionally served as focal energy-balance behaviors targeted in childhood obesity research, studies demonstrating secular decreases in children's sleep duration have hence introduced this emerging construct to this list. According to the latest national poll, the average child in the United States obtains up to 1.6 hours less sleep than he or she is recommended.^{8,9}

In light of these findings, in 2008, Hart and Jelilian^{10,11} published the first review that collected cross-sectional, prospective, and experimental evidence linking child sleep duration and adiposity. Several additional reviews linking child sleep duration and obesity were published that same year.^{12–14} A 2016 meta-analysis by Yoong et al.¹⁵ complemented these findings by further suggesting that interventions promoting child sleep duration may also improve children's BMI and dietary and physical activity behaviors.

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More recent reviews¹⁶ have since expanded the meaning of child sleep to include constructs beyond simply sleep duration, such as bedtime routines.

As with other energy-balance behaviors, families hold a potential to promote sleep in children, such as through the establishment of bedtime routines, appropriately addressing night wakings, and limiting media use before bed.¹⁷ However, while sleep is increasingly recognized as an important risk factor for childhood obesity¹⁵ and the family unit is widely acknowledged as a critical agent of change for its prevention,¹⁸ the extent to which sleep has been integrated into family-based childhood obesity interventions is unclear. Prior reviews have predominately focused on the *effectiveness* of sleep interventions to promote healthy weight gain in children.^{15,16}

For example, Yoong et al.¹⁵ published a systematic review and meta-analysis of interventions that target sleep to examine their impact on child BMI, diet, and physical activity. Also, while Busch et al.¹⁶ reviewed the characteristics of interventions that targeted sleep in children, in addition to their effectiveness, they did not include children from birth to 5 years and, like other reviews, did not examine sleep within the context of family-based obesity interventions. More importantly, both studies relied on search terms for sleep, which may have limited the variation of their findings and prevented them from presenting data on the prevalence of sleep promotion in the literature.

While additional review on the effectiveness of sleep promoting interventions holds merit, the growing discourse around sleep promotion in child populations begs for greater reflection of precisely how, and how many, such studies are promoting sleep, to pave the way for future interviews and reviews.

Focusing on children from birth to 17 years, this study examines the inclusion of sleep promotion in family-based interventions to prevent childhood obesity published since the first systematic reviews in 2008.^{10,12–14} We pose the following two questions: (1) What proportion of interventions promoted child sleep, out of all family-based interventions to prevent childhood obesity? and (2) How has sleep promotion been integrated, by way of strategies, designs, and measures, into family-based interventions to prevent childhood obesity? To the best of our knowledge, ours is the first study to review sleep's *inclusion* in family-based obesity interventions. Insight to these questions will guide the development of future family-based obesity interventions.

Methods

Study Selection and Data Extraction

This study draws on data from a recent systematic review and content analysis of family-based interventions for childhood obesity prevention completed by our research team⁷ and adds new data on sleep promotion methods. The procedures used to compile data for this study are summarized in Figure 1 and described below.

Original systematic review. Detailed description of the systematic review methods is provided in Ash et al.⁷ PUBMED, PSYCINFO, and CINAHL databases were searched with assistance from a research librarian. Eligible articles included original studies describing family-based interventions to prevent childhood obesity in the English language between January 1st, 2008, and December 31st, 2015.

“Family based” was defined as the *active* and *repeated* involvement by parents or legal caregivers. To be eligible as an obesity intervention, a study had to self-identify as one or report at least one weight-related outcome (e.g., BMI), which limited potential studies to those using quantitative measures. Interventions were considered preventative if they were designed to avoid further weight gain. Interventions also had to be designed to benefit children, or participants younger than 18 years of age.

Studies were excluded if parental involvement was passive, if only outcomes for obesity risk factors (e.g., diet) were reported, if studies focused on weight management or recruited exclusively children with obesity, or if studies only targeted weight-related outcomes in parents. Intervention protocols were eligible for inclusion to ensure the latest research was represented. After removing duplicates, a total of 9152 articles were screened and 159 articles representing 119 unique interventions were identified.

Content analysis¹⁹ was used to code intervention characteristics for the eligible interventions. Using a standardized codebook and following the establishment of intercoder reliability,⁷ trained coders recorded over 90 variables for article, intervention, and participant characteristics. Specifically, three coders screened 9152 articles against the eligibility criteria, and then, two coders (A.A. and T.A.) screened the 159 articles or 119 unique interventions that passed criteria.

Data for nine variables were utilized in this study, including the following: first author, intervention name, geographic region (*i.e.*, country), study design [*i.e.*, randomized controlled trial (RCT)], child age group targeted (*i.e.*, pre-natal, 0–1 year, 2–5 years, 6–10 years, 11–13 years, or 14–18 years), intervention setting (*i.e.*, clinic, home, community, school, or not specified), baseline sample size, and publication type (*i.e.*, intervention protocol or results). Coders also recorded the four, targeted energy-balance behaviors (*i.e.*, diet, physical activity, media use, and sleep). Multiple behaviors, as well as age groups and intervention settings, could be selected for a single intervention.

Consistent with Halal and Nunes²⁰ conceptualization of “sleep hygiene,” sleep promotion was coded if the intervention addressed child or parenting practices specific to sleep (e.g., soothing activities or bedtime routines) or sleep environments that influence sleep quality or duration (e.g., a television in room where child sleeps). When sleep was indirectly targeted through another energy-balance behavior (e.g., removing the television from the room where the child sleeps), the intervention was coded as targeting child sleep only if it explicitly indicated that activities were undertaken for the direct purpose of sleep promotion.

Figure 1. Overview of data compilation process.

This review. All interventions ($n=119$) identified by Ash et al.⁷ were eligible for inclusion in this review. Data for intervention length and theory coded in the original review were excluded. Intervention length would be more relevant for a review of intervention outcomes. Furthermore, rather than referring to self-reported theory, we examined theory based on how studies targeted, designed, and measured sleep promotion.

We also excluded data that were only coded for studies that reported outcomes, which included the representation of underserved populations, nontraditional families, and racial/ethnic groups. These data are less meaningful for a review with few studies that report outcomes; instead, we descriptively synthesized target participant demographics.

We expanded the original search for intervention protocols ($n=33$) in the case they had subsequently published results. We also searched the gray literature by reviewing the references of eligible studies and relevant review articles. Data on energy-balance behaviors targeted in each interven-

tion, previously coded by Ash et al., were then utilized to identify interventions that targeted child sleep. For these interventions, two coders (A.A. and M.S.) then coded a subset of five articles for characteristics not captured in Aim 1, including the following: (1) study arms, which were used as a proxy for understanding how studies were designed to promote sleep; (2) sleep promotion strategy, separated into diet, physical activity, screen time, behavioral management, routines, sleep education, and “other”; and (3) sleep-related measures for mother and child, separated by the type of measurement (e.g., objective actigraphy or survey).

Of note, data for measures of parent sleep were coded because parental sleep measures are indication that researchers targeted parental sleep or hypothesized a change in their sleep behaviors. This is important in family-based interventions where change in children behaviors is dependent on the greater family context, such as parental modeling of sleep or parental sleep impacting other parenting behaviors

(e.g., feeding). From these data, the two coders developed a codebook and remaining articles were coded and synthesized by A.A., with consultation from the second coder and repeated meetings with the greater team.

Data Synthesis

To assess the extent to which sleep was promoted in family-based interventions to prevent childhood obesity, we calculated the percentage (%) of interventions that promoted sleep among all intervention from the original review ($n=119$). We also descriptively compared the proportion of interventions targeting sleep in relation to diet, physical activity, or media use, as well as their numerical overlap, in a Venn diagram (Fig. 2).

Focusing specifically on interventions that promoted child sleep and using frequency tabulations in STATA, we created a quantitative summary of intervention characteristics, including geographic region, target population, target child age, intervention setting, remote delivery method, study design, and publication type (Table 1). To avoid repetition of otherwise nonvariable findings, we did not report findings by age group; rather, any discrepancy regarding our findings in relation to age groups was highlighted in each section of our findings, as relevant.

In addition, we compiled a descriptive summary of intervention characteristics (Table 2). Finally, Table 3 shows how interventions integrated sleep promotion in their study arms, sleep promotion strategies, and participant outcomes measures.

Figure 2. Intersectionality of behavioral targets in family-based interventions to prevent childhood obesity published between June 1, 2008, and December 31, 2015 ($n=118$). Total number of interventions amounts to $n=118$ because 1 ($n=1$) of 119 interventions⁴⁸ did not target any of the 4 energy-balance behaviors (*i.e.*, diet, physical activity, media use, or sleep). Smaller circles refer to overlap between studies that target physical activity and media use ($n=2$) and diet and sleep ($n=3$).

Table 1. Summary of Characteristics of Family-Based Interventions to Prevent Childhood Obesity that Promoted Sleep ($n=24$)

Study characteristics	N
Geographic region	
USA	14
Canada	1
Europe	
Nordic countries	5
Netherlands	1
Pacific Islands	
Australia	2
New Zealand	1
Target population ^a	
Low-income or minority families	13
Pregnant women or new mothers	9
Overweight or obese parents	6
Single mothers	1
Not specified	1
Target child age, years ^{b,c}	
Prenatal	5
0–1	9
2–5	18
6–10	2
11–13	0
14–18	0
Intervention setting ^c	
Clinic	12
Home	9
Community centers (e.g., library)	5
School	3
Not specified	1
Predominately remote delivery	
Mobile app, website, or mail	3
Study design	
RCT	17
RCT with sleep promotion study arm	2
Publication type	
Only intervention protocol available	11

^aStudy may fall into more than 1 category.

^bAge must fall at least 2 years into specified range to be considered for age range.

^cStudy may fall into more than one category.
RCT, randomized controlled trial.

Table 2. Overview of Characteristics for Family-Based Interventions to Prevent Childhood Obesity that Promoted Sleep (n = 24)

Author ^a	Study name	Region	Design	Target population	Baseline, N
Savage et al. ^{26,45}	INSIGHT	USA	2-Arm RCT	First-time mothers and their newborns (0–3 years of age) recruited from a maternity ward in Hershey, PA	291 Mother-infant dyads
Fangupo et al. ^{29,48}	POI.nz Study	New Zealand	2 × 2 Factorial	Pregnant women and their newborns (0–2 years of age) recruited through the only maternity unit in Dunedin	802 Mother-infant dyads
Nyberg et al. ^{21,22}	A Healthy School Start	Sweden	2-Arm cluster RCT	Families with 6-year-old children attending schools in low-income districts of Stockholm	243 Children and their parents
Skouteris et al. ^{27,28}	MEND	Australia	2-Arm RCT	Children 2–4 years of age and their parents attending MEND 2–4 program in metropolitan and regional Victoria	201 Parent-child dyads
Walton et al. ⁴⁹	PTT	Canada	2-Arm RCT	Parents of preschoolers 2–5 years of age attending Ontario Early Years centers in southwestern Ontario	48 Parent-child dyads
Dawson-McClure et al. ²⁵	ParentCorps (Enhanced)	USA	Pre-post	Parents of pre-K students (average: 4 years) in six public elementary schools in low-income communities of NYC	91 Children and their families
Weaver et al. ⁵⁰	FHFC	USA	Pre-post	Children 4–10 years of age with BMI ≥85th percentile with at least one family member with BMI >28, in a family medicine residency training program in the McLennan County, Texas, a Federal Health Professions Shortage Area	8 Families, including 17 children and 10 parents
Haines et al. ^{39,40}	Healthy Habits, Happy Homes	USA	2-Arm RCT	Families with children 2–5 years of age that had a TV in the room where they slept, recruited from health centers serving predominately low-income and minority families in Boston, MA	121 Parent-child dyads
Koulouglioti et al. ³⁶	Not specified	USA	Pre-post	Single mothers and children 3–5 years of age recruited through Head Start center in upstate NY	11 Mother-child dyads
Mustila et al. ^{43,51}	VACOPP study	Finland	2-Arm nRCT	Pregnant women at risk of gestational diabetes and their newborns (0–5 years of age) recruited from maternal healthcare clinics in the city of Vaasa	185 Mother-child dyads
Slusser et al. ²³	Healthy Parenting Workshops	USA	2-Arm RCT	Low-income Latino mothers and their 2- to 4-year-old children recruited through healthcare clinics and community sites in Los Angeles, CA	160 Mother-child dyads
Paul et al. ³⁴	SLIMTIME	USA	2 × 2 Factorial	Mothers intending to breastfeed and their newborns (0–2 years of age) recruited from one maternity ward in Hershey, PA	160 Mother-infant dyads
Taveras et al. ²⁴	First Steps for Mommy and Me	USA	2-Arm nRCT	Mothers and their newborns (0–6 months of age) recruited through Harvard Vanguard Medical Associates pediatric care offices in Boston, MA	84 Mother-infant pairs
Only protocol available					
Cloutier et al. ³³	ECHO	USA	2-Arm RCT	Pregnant women and new mothers within 1 month of delivery and their Latino or black newborns (ages 0–1 year) enrolled in the Nurturing Families Network home visitation program, living in six low-income urban neighborhoods in Hartford, CT	49 Mother-child dyads ^b

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Table 2. Overview of Characteristics for Family-Based Interventions to Prevent Childhood Obesity that Promoted Sleep (n = 24) *continued*

Author ^a	Study name	Region	Design	Target population	Baseline, N
Only protocol available					
Delisle et al. ⁴⁴	MINSTOP	Sweden	2-Arm RCT	Parents and caretakers and their 4-year-old children living in Ostergotland province recruited from a population register (RURAL)	N/A (protocol)
Denney-Wilson et al. ⁵²	The Growing Healthy Study	Australia	2-Arm nRCT	Parents (pregnant or caregivers of infant younger than 3 months of age) from MCH service centers, outpatient antenatal service centers, and general practices in socioeconomically disadvantaged areas of Melbourne and North South Wales	N/A (protocol)
Kaiser et al. ^{42,53}	Niños Sanos, Familia Sana (Healthy Children, Healthy Family)	USA	2-Arm nRCT	Mexican-origin children 2–5 years of age and their families predominately working in agriculture and living in two rural school communities in Central Valley, CA	N/A (protocol)
Po'e et al. ³⁰	GROW	USA	2-Arm RCT	Latino or African American normal-weight and overweight children 3–5 years of age and their parents/caregivers living in predominately underserved neighborhoods of Davidson County, TN	N/A (protocol)
Raat et al. ³⁵	BeeBOFT	Netherlands	3-Arm cluster RCT	Parents and their newborns (0–3 years of age) attending Youth Health Care centers after child birth in rural and urban Rotterdam	N/A (protocol)
Karanja et al. ³⁸	PTOTS	USA	2-Arm RCT	Pregnant women in their 2nd or 3rd trimester and their newborns (0–3 years of age) living in 5 American Indian tribes, recruited from Maternal Child Health clinics and the Women, Infants, and Children program in Portland, OR	N/A (protocol)
Olsen et al. ³⁷	Healthy Start (“Sund Start”)	Denmark	3-Arm RCT	Normal-weight children 2–6 years of age at risk for overweight and their parents (who were overweight before pregnancy), recruited through the Danish National Birth Registry	543 Children and their parents (+394 “shadow” control group) ^b
Østbye et al. ⁵⁴	Kids and Adults Now! Defeat Obesity	USA	2-Arm RCT	Postpartum women overweight or obese before pregnancy and their children 2–5 years of age, in 14 counties of the Triangle and Triad regions of North Carolina, USA	400 Mother-child dyads
Sobko et al. ³¹	Early STOPP	Sweden	2-Arm RCT	Overweight and/or obese parents with infants 1–6 years of age, recruited from Child Health Care centers in Stockholm	N/A (protocol)
Ward et al. ³²	My Parenting SOS	USA	2-Arm RCT	Families with at least one overweight parent and their 2- to 5-year-old children, recruited through counties with a large percentage of minority residents in central NC	N/A (protocol)

^aIf search retrieved more than one article for the same study, the first author of the latest publication year was listed.

^bProtocol reported N at baseline.

BeeBOFT, breastfeeding, breakfast daily, outside playing, few sweet drinks, less TV viewing; ECHO, Early Childhood Obesity Prevention Program; FHFC, Fit and Healthy Family Camp; GROW, Growing Right Onto Wellness; INSIGHT, Intervention Nurses Start Infants Growing on Healthy Trajectories; KAN-DO, Kids and Adults Now! Defeat Obesity; MEND, Mind Exercise Nutrition Do It!; MINSTOP, Mobile-based Intervention Intended to Stop Obesity in Preschoolers; N/A, not applicable; nRCT, non-randomized controlled trial; POI.nz, Prevention of Overweight in Infancy; PTOTS, Prevention of Toddler Obesity and Teeth Health Study; PTT, Parents and Tots Together; RCT, randomized controlled trial; SCT, social cognitive theory; SLIMTIME, SLeeping and Intake Methods Taught to Infants and Mothers Early in life; STOPP, STockholm Obesity Prevention Program; VACOPP, VAasa Childhood Obesity Primary Prevention.

Table 3. Integration of Sleep Promotion in Family-Based Interventions to Prevent Childhood Obesity (n = 24)

Author ^a	Study arms	Design	Sleep promotion strategy	Sleep measure (child)	Sleep measure (parent)
Savage et al. ^{26,45}	Intervention: Home and clinic visits for parents on 4 child behavior states (Sleeping, Fussy, Alert and Calm, and Drowsy) to promote responsive parenting, plus growth charts; Control: Home safety	2-Arm RCT	Diet: Nonfeeding soothing techniques; hunger/sleepy cues; Routines: Bedtime rituals; Sleep: Age-appropriate sleep duration; profile; transitions	Survey: Brief Infant Sleep Questionnaire; Bedtime Routines Questionnaire	Survey (mother): Sleep Disturbance and Sleep-Related Impairments item banks
Fangupo et al. ^{29,48}	FAB: Extra Well Child home visits for mothers on breastfeeding, diet, and PA; Sleep: Regular Well Child home visits for mothers on child sleep, plus booklet; Combo: Combination; Control: Usual care	2 × 2 Factorial	Behavioral Management: Emerging sleep problems trigger intensive intervention (i.e., extinction); Sleep: Parenting (e.g., put to bed awake; day–night differences; bed-sharing)	Actigraphy: Actual activity monitor (5-day at w/2-day diary) Survey: Questionnaire (validated; not specified): sleep duration and onset latency; wakings; routines; safe sleep	Survey (mother): Questionnaire (not specified): Same, plus self-rated adequacy of sleep duration and quality; Brief Fatigue Assessment Scale: parent fatigue levels
Nyberg et al. ^{21,22}	Intervention: Motivational interviewing with parents on child diet, PA, and sleep, plus class activities and pamphlet; Control: Usual classroom, plus delayed intervention	2-Arm cluster RCT	Sleep: Importance of child sleep; age-appropriate sleep duration (optional)	Survey: Modified Eating and Physical Activity Questionnaire: sleep duration ^b	Survey (parent ^c): Tool to Measure Parenting Self-Efficacy: self-efficacy to regulate child's sleep behavior
Skouteris et al. ^{27,28}	Intervention: Family workshops in community or maternal and child health centers on child diet, PA, screen time, and sleep and parenting behaviors; Control: Delayed intervention	2-Arm RCT	Behavioral Management: Tantrums at bedtime; Routines: Bedtime rituals; Screen Time: Limit TV before bed Sleep: Age-appropriate sleep duration ^b	Not specified	Not specified
Walton et al. ⁴⁹	Parents and Tots Together: Nine family-based group sessions related to parental roles in promoting healthy nutrition, PA, media use, and routines, tailored to the Canadian population; Attention-Matched Control: Nine-week home safety intervention	2-Arm RCT	Sleep: Bedtime routines	Survey: Questionnaire (not specified): sleep duration (weekday day/night and weekend day/night)	Not specified
Dawson-McClure et al. ²⁵	Intervention: Group series for parents and children at schools on parenting and behavioral dysregulation on diet, PA, and sleep in child	Pre-post	Routines: Bedtime rituals ^b Screen Time: Limit TV before bed; Sleep: Age-appropriate sleep duration	Survey: Children's Sleep Habits Questionnaire: Bedtime Resistance subscale (6 item)	Not specified
Weaver et al. ⁵⁰	Intervention: Eight monthly sessions that combined family group medical visits with “healthy living workshops” on the topics of diet, PA, sedentary behavior, and emotional well-being.	Pre-post	Sleep: Education on sleep hygiene as part of a session on “emotional well-being”	Not specified (quality of life)	Not specified (quality of life)

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Table 3. Integration of Sleep Promotion in Family-Based Interventions to Prevent Childhood Obesity (n = 24) continued

Author ^a	Study arms	Design	Sleep promotion strategy	Sleep measure (child)	Sleep measure (parent)
Haines et al. ^{39,40}	Intervention: Motivational interviews, materials, and text messages to promote routines, sleep, and remove TV from child's bedroom; Control: Mailed child development materials	2-Arm RCT	Routines: Bedtime routines activity and children's book; Screen Time: Remove TV from room child sleeps; Sleep: Age-appropriate sleep duration; booklet	Survey: Questionnaire (not specified): sleep duration; TV in room where child sleeps (inclusion criteria); co-sleeping (baseline only)	Not specified
Kouloughioti et al. ³⁶	Intervention: Tailored strategies and education for improving children's sleep and eating routines delivered to mothers during home visits	Pre-post	Routines: Child bedtime routines with personalized action plan; treating bedtime as quality time Sleep: Benefits of child sleep	Actigraphy: Mini-Motionlogger Actigraph watch (3-day with diary); Survey: Children's Sleep Hygiene Scale: Bedtime Routines (2 items) and Sleep Stability subscales (5 items); Children's Sleep-Wake Scale: Going to Sleep subscale (5 items); Child Sleep Habits Questionnaire: Bedtime Resistance subscale (6 item)	Not specified
Mustila et al. ^{43,51}	Intervention: Counseling sessions for mothers on diet and PA at maternity clinics, plus leaflets on breastfeeding; child counseling session on diet, PA, screen time, and sleep, plus 30- to 60-minute longer visits and pamphlets; Control: Usual care	2-Arm nRCT	Sleep: Age-appropriate "sleeping patterns" (not specified)	Survey (Child): Questionnaire (not specified): sleep duration	Survey (mother): Questionnaire (not specified): sleep duration (1st-3rd trimesters of pregnancy)
Slusser et al. ²³	Intervention: Group training sessions in community and maternal and child health clinics on food, PA, media, and sleep parenting, plus handouts; Control: Usual care, delayed intervention, plus pamphlet	2-Arm RCT	Routines: Bedtime strategies; bedtime routines in busy schedule; Sleep: Age-appropriate child sleep duration	Not specified	Not specified
Paul et al. ³⁴	Soothe/Sleep: Home visits to minimize feeding that disrupts infant sleep, plus handout and a commercial video; Introduction of Solids: Home visits to promote distinction between hunger and satiety, proper timing for solids, and overcoming picky eating in infants; baby food and instructions supplied; Combo: Combination; Control: Usual care, breastfeeding support, and parent book and handouts on solids and handling night wakings	2 × 2 Factorial	Behavioral Management: Responding to night wakings; parent book; Diet: nonfeeding soothing strategies; recognition of hunger versus other distress (e.g., sleepiness); commercial video; Routines: Emphasize day-night differences;	Diary Cards: 96-Hour Diary Cards: infant behavior status (e.g., sleeping) in 15-minute intervals; Survey: Infant Behavior Questionnaire: infant soothability and nocturnal feedings	Not specified

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Table 3. Integration of Sleep Promotion in Family-Based Interventions to Prevent Childhood Obesity (n = 24) continued

Author ^a	Study arms	Design	Sleep promotion strategy	Sleep measure (child)	Sleep measure (parent)
Taveras et al. ²⁴	Intervention: Focused negotiation during regular well child care visits, motivational interviewing phone calls, parenting skills workshop, and handouts on mother and infant's diet, screen time, sleep, and PA; Control: Usual care	2-Arm nRCT	Diet: Reduce caffeine before bed; nonfeeding soothing strategies; Routines: Managing bedtime in busy schedule; Screen Time: Removing TV from child bedroom; limit TV before bed; Sleep: Child and mother recommended sleep duration; sleep autonomy	Survey: Brief Infant Sleep Questionnaire; Questionnaire (not specified): television in room where child sleeps	Survey (mother): Questionnaire (not specified): sleep duration
Only protocol available					
Cloutier et al. ³³	Intervention: Home visitation program with breastfeeding support, introducing solids, intake of juice and SSBs, sleep, response to infant cues, screen time, and maternal diet and PA, plus a family wellness plan, "toolkit," and links to resources; Control: Standard home visitation program	2-Arm RCT	Diet: Nonfeeding soothing strategies; Routines: Sleep parenting skills to promote child bedtime routines; Screen Time: Removing TV from child's bedroom; Sleep: Age-appropriate sleep duration; sleep toolkit (sleep sack and picture of baby sleeping)	Survey: Brief Infant Sleep Questionnaire; Infant Behavior Questionnaire: Revised: Infant Soothability domain	Not specified
Delisle et al. ⁴⁴	Intervention: Tailored text messages and feedback to parents through app on diet, PA, and sleep in children; Control: Pamphlet on healthy diet and PA	2-Arm RCT	Sleep: Not specified	Actigraphy: Actigraph GT3X-BT (7-day with diary) ^b	Not specified
Denney-Wilson et al. ⁵²	M-health Intervention: New mobile app, website, and online forum provide parents from one of three health centers with evidence-based advice on infant feeding, such as breastfeeding, best practice formula feeding, delaying introduction of solids, promoting healthy foods, first, and exposure to new foods; Comparison: Usual care	2-Arm nRCT	Diet: Nonfeeding soothing strategies (e.g., prevent formula or early solids); recognition of satiety cues; Sleep: Age-appropriate sleep patterns	Not specified	Not specified
Kaiser et al. ^{42,53}	Intervention: Community intervention with nutrition family nights, school nutrition and PA curricula, fruit and vegetable vouchers, and community art; Control: Comparison area	2-Arm nRCT	Routines: Child bedtime routines; Screen Time: Reducing TV watching before bedtime	Actigraphy: PolarActive activity monitor (7-day, annually for years 1–5; subsample: n = 150; child age = 4–7 years) ^b	Not specified

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Table 3. Integration of Sleep Promotion in Family-Based Interventions to Prevent Childhood Obesity (n = 24) continued

Author ^a	Study arms	Design	Sleep promotion strategy	Sleep measure (child)	Sleep measure (parent)
Only protocol available					
Po'e et al. ³⁰	GROW Healthier: Direct and phone family coaching sessions on food, PA, sleep, and parenting practices at recreation centers plus child PA sessions and booklets; Control: School readiness program	2-Arm RCT	Sleep: Intensive phase had lessons, goal setting, and hands-on activities on sleep (not specified); booklet on importance of sleep and age-appropriate sleep duration; "tangible tool" to reinforce messages (not specified) Routines: Sleep parenting (e.g., late feeding; bedtime rituals); fixed order; Sleep: Sleep duration; sleep parenting practices (e.g., putting baby to sleep awake, gradually reducing sleep in afternoon)	Actigraphy: Actigraph GT3X+ activity monitor (7-day); Survey: Questionnaire (not specified): bedtime routines	Actigraphy (parent ^c): Actigraph GT3X+ activity monitor (7-day)
Raat et al. ³⁵	BBOFT-4: Parent counseling on breastfeeding and food, PA, screen time, and sleep parenting in routine visits to Youth Healthcare through visual; E-health4Uth Healthy Toddler: Education on child diet, PA, and screen time through website, plus in-person/e-mail; Control: Usual care	3-Arm cluster RCT		Survey: Questionnaire (unspecified): based on pilot; sleep duration/bedtime; sleep-onset latency; night wakefulness; sleep problems; feeding before/after bedtime ^b	Not specified
Karanja et al. ³⁸	Intervention: Home family counseling sessions for 3 tribes on breastfeeding, SSBs, introduction of solids, and sedentary lifestyles in children, plus community breastfeeding intervention; Control: Dental screenings for 2 tribes	2-Arm RCT	Diet: Infant sleep problems and fussiness in relation to infant feeding; nonfeeding soothing strategies	Not specified	Not specified
Olsen et al. ³⁷	Intervention group: Motivational interviewing in family clinic visits on diet, PA, sleep, and stress, plus invitations to cooking classes and play groups; Control group: Children examined by health consultant start and end of trial; Shadow control group: Child register cohort	3-Arm RCT	Physical Activity: Increase PA during daytime; Routines: Bedtime rituals; Screen Time: Limit TV before bed; Sleep: "Keywords" and "tools" in motivational interviewing on sleep quality (not specified); Other: Improve emotional environment of home	Actigraphy: Actigraph GT3X activity monitor (5-day with 7-day diary; subsample: n = 79); Survey: Questionnaire (not specified): sleep quality and problems; Other: Saliva samples: sleep quality markers (clock genes and melatonin)	Other (parent ^c): Saliva samples: sleep quality markers (clock genes and melatonin)
Østbye et al. ^{54,55}	KAN-DO Intervention: Eight mailed family kits and telephone calls, plus one class, to build parenting skills, promote routines, build supportive environments, and role model healthy diet, PA, media use, and sleep. Minimal Care: Monthly newsletters on prereading skills.	2-Arm RCT	Routines: Bedtime routines	Survey: Child Sleep Habits Questionnaire: Bedtime Resistance Subscale	Not specified

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Table 3. Integration of Sleep Promotion in Family-Based Interventions to Prevent Childhood Obesity (n = 24) continued					
Author ^a	Study arms	Design	Sleep promotion strategy	Sleep measure (child)	Sleep measure (parent)
Only protocol available Sobko et al. ³¹	Intervention group: Motivational interviewing with parents at child healthcare centers (or home) targeting diet, PA, screen time, and sleep parenting, plus educational booklets; Control group: Usual care	2-Arm RCT	Behavioral Management: Extinction; Routines: Bedtime routines	Actigraphy: ActiGraph GT3X+ activity monitor (7-day; child age = 2 years) Survey: Brief Infant Sleep Questionnaire (7-day)	Actigraphy: ActiGraph GT3X+ activity monitor (7-day; child age = 2 years) Survey: Karolinska Sleep Quality Index; Karolinska Sleep/Wake Diary
Ward et al. ³²	Intervention Group: In-person group meeting and tailored phone calls with parents targeting parenting skills (stress management, effective parenting styles, child behavior management, co-parenting, and time management) and health behaviors food, PA, screen time, and sleep parenting), plus a child program targeting diet and PA; Control Group: Children's book club	2-Arm RCT	Behavioral Management: Limit child from getting up at night; Routines: Bedtime routines; Sleep: Duration; Diet: Infant sleep problems and fussiness in relation to infant feeding; nonfeeding soothing strategies	Not specified	Not specified

^aIf search retrieved more than one article for the same study, the first author of the latest (year) publication was listed.

^bAdditional study information was retrieved through contact with study authors.

^c“Parent” indicates authors were not explicit about gender of adult caregiver sample.

nRCT, nonrandomized controlled trial; PA, physical activity; TV, television.

Results

What Proportion of Interventions Promoted Child Sleep, Out of All Family-Based Interventions to Prevent Childhood Obesity?

A total of 24 out of 119 interventions (20.2%) promoted sleep. In contrast, diet, physical activity, and media use were targeted in 106 (89.1%), 97 (81.5%), and 63 (52.9%) of the 119 interventions, respectively. As shown in Figure 2, all 24 interventions that promoted sleep also targeted diet, physical activity, or media use, and most interventions that promoted sleep ($n = 17$) were those that targeted all 4 energy-balance behaviors.

Looking at the interventions that promoted sleep (Table 1), the majority (58%) were conducted in the United States, followed by Europe (25%)—specifically Nordic countries. Interventions commonly recruited low-income or minority families (43%) and targeted children below 5 years of age (53%), including pregnant women and children younger than 1 year; only two studies (6%) targeted children 6–10 years of age and none older than 10 years. Interventions were predominately conducted in clinical or home-based settings (72%). Most interventions were RCTs (70%). Nearly half of all interventions (46%) were study protocols that did not have published outcome evaluation data.

How Is Sleep Promotion Integrated, By Way of Strategies, Designs, and Measures, Into Family-Based Interventions to Prevent Childhood Obesity?

Sleep promotion strategies. Among interventions that promoted child sleep ($n = 24$), a wide range of sleep promotion strategies were utilized. A majority of interventions (17 out of 24) directly educated parents on sleep hygiene, such as age-appropriate sleep duration, the health benefits and the consequences of sleep behaviors, and soothing strategies.^{21–32} Few interventions described ways by which sleep hygiene was communicated. One study distributed a commercially produced video on soothing strategies, a children's bedtime story book, and a sleep parenting self-help book.²⁴ Some studies also offered resources to reinforce sleep hygiene, such as a picture of their baby sleeping or a sleep sack,^{24,33} and collectively marketed these materials as a “sleep toolkit.”³³ The remainder of this section summarizes less direct sleep promotion strategies.

More than half of all interventions ($n = 14$) promoted sleep in the context of “healthy family routines.” For example, parents were taught to maximize day/night differences,^{29,34} to put their child to bed while still awake,^{24,29,35} and to gradually reduce their child's sleep in the afternoon.³⁵ One intervention instructed parents in morning as well as nighttime routines.²³

Seven interventions leveraged routines as a way of recognizing families' structural challenges,^{23–25,29,32,36,37} including crowding, work schedules, and noise pollution. For example, two suggested parents schedule their child's nap when they do household chores^{23,24} and one marketed

bedtime routines as family bonding opportunities.³² Five interventions instructed parents in behavioral management techniques to alleviate bedtime problem behaviors,^{27–29,31,32,34} such as repeatedly getting out of bed and throwing tantrums. Of note, four interventions offered personalized materials to promote sleep routines, such as a goal-setting child “sleep profile,”^{26,30,33} a family mapping activity of evening routines,²⁵ and a “bedtime routines clock” activity.³⁹

As previously noted, all interventions that promoted sleep also targeted diet, physical activity, or media use, and hence sleep was often promoted in conjunction with other energy-balance behaviors. One in four interventions ($n = 6$) instructed parents in sleep parenting practices that sought to disentangle feeding from child's sleep. All six promoted sleep by instructing parents on how to respond to their children's behavioral states using nonfeeding soothing strategies.^{24,26,33–35,38}

In the INSIGHT (Intervention Nurses Start Infants Growing on Healthy Trajectories) study,²⁶ mothers randomized to the sleep arm of the intervention were trained in distinguishing between child behavioral states to reduce instances of inappropriately feeding their children in response to nonhunger behavioral cues.

Four interventions specifically encouraged parents to avoid feeding during night wakings.^{24,26,34,38} Interventions also instructed parents on “dream feeds” (*i.e.*, “waking the baby to feed before the parent goes to bed”),²⁶ as well as proper bedtime positions for their child, checking for dirty diapers before bed, and using white noise machines, as well as rocking, shushing, swinging, and swaddling techniques.^{26,34}

A third of interventions promoted sleep by intervening in media use ($n = 8$), most commonly by recommending that parents remove the television from the room where their children sleep or limit their children's media use before bed.^{24,25,27,28,33,34,37,39–42} In First Steps for Mommy and Me, authors sent text messages to parents that read, “Mommy, I can't sleep... [television] at bedtime makes it harder for kids to relax and go to sleep...”²⁴ While most referred specifically to television, one intervention referenced computers and video games.³⁷

Finally, only one intervention promoted child sleep through physical activity.³⁷ In one of five motivational interviewing “tools,” parents in the Healthy Start (“Sund Start”) intervention were advised to increase their child's physical activity during the daytime, specifically to promote sleep at night.

Sleep promotion strategies did not vary wildly by age group, but those targeting newborns and children 2–5 years of age promoted sleep by more numerous strategies than studies targeting only older children. For example, although few of such studies, two^{21,22,50} that targeted 4–10 year olds and 6-year olds only promoted sleep by educating parents about child sleep, compared to studies that channeled sleep promotion through routines, diet, and screen time, among other behaviors and in different combinations. Little variation was evident for studies targeting infants

versus children 2–5 years of age, with the exception of studies that targeted infants more commonly targeting sleep by way of diet, especially infant feeding. However, many such studies were still in the form of protocols.

Study designs utilized. Studies were generally not designed to assess the effect of sleep promotion on child weight gain independent of other energy-balance behaviors, given that all, but five examined sleep promotion alongside strategies targeting other energy-balance behaviors in a single study arm. Sleep promotion more often appeared as a theme of home visits or workshops, like in the GROW (Growing Right Onto Wellness) trial,³⁰ where 1 of 12 parent coaching sessions was centered around sleep promotion (“Sleep Matters”).

A number of studies also reserved sleep promotion to an overarching target, focus area, or message; one of four “messages” offered to parents during counseling sessions in the VACOPP (VAasa Childhood Obesity Primary Prevention) study⁴⁴ pertained to sleep promotion, while the remaining three focused on diet, physical activity, and media use.

Finally, in two interventions, sleep promotion was integrated into less intensive components while a more intensive sleep intervention was “optional.”^{21,22,41} Two exceptions include POInz (Prevention of Overweight in Infancy) and the SLIMTIME (SLeeping and Intake Methods Taught to Infants and Mothers Early in life),³⁴ which examined the effect of sleep promotion independent of other activities on child weight gain in a separate study arm. In both, groups exposed to food parenting, sleep parenting, or both were compared to a control group. Both studies targeted newborns 0–2 years of age. Most studies that targeted children 2–5 years of age were RCTs. Studies with older children varied in study design.

Measurement of sleep-related behaviors. Four interventions did not reference a measure of child sleep and most did not report measuring parent sleep.^{23,27,32,38} Of the 17 (81%) that reported measuring child sleep, most ($n = 15$) used parent report. One-third ($n = 7$) used nonvalidated or unspecified questionnaires.^{24,29,30,35,39,41,43} Slightly more than a third of studies measured sleep using actigraphy ($n = 8$).^{29,31,36,37,41,42,44,45} One intervention that targeted newborns 0–2 years of age measured sleep using ecological momentary assessment,³⁴ but otherwise the type of sleep measure was unrelated to the age group of the child.

Most interventions measured child sleep duration ($n = 15$, or 71%), followed by settling time (*i.e.*, sleep onset latency) ($n = 5$),^{24,31,34–36} night wakings ($n = 4$),^{24,29,35,38} sleep efficiency (*i.e.*, relative sleep vs. awake time in bed; $n = 3$),^{29,31,37} soothability ($n = 2$),^{33,34} and sleep problems (*i.e.*, bedtime resistance; nightmares; $n = 5$).^{25,35–37,41}

Interventions also reported measuring children’s sleep context, including bedtime or nighttime routines,^{26,29,30,36,37} and the presence of a television in the room where the child sleeps.^{24,39,41} One study measured biological markers of child sleep using clock genes and melatonin from saliva

samples.³⁷ Studies targeting younger children tended to focus on measures of sleep quality, over sleep behaviors or context.

Most interventions ($n = 12$, or 57%) did not report measuring sleep-related constructs in parents. Of nine that did, six used self-report measures,^{21,24,26,29,31,43} most ($n = 5$) of which were nonvalidated or unspecified,^{21,24,26,29,43} with no two interventions utilizing the same type of questionnaire. Measure of parent sleep did not appear to be related to the child age group. Three interventions measured sleep in parents by actigraphy^{31,41,45} and one by biological markers from saliva samples.³⁷ Interventions generally measured parent sleep duration ($n = 4$),^{24,29,41,43} sleep problems (*i.e.*, trouble falling asleep), daytime fatigue ($n = 4$),^{26,29,31,41} sleep efficiency ($n = 1$),²⁹ night wakings ($n = 1$),²⁹ and whether or not parents took naps ($n = 1$).³¹

Discussion

In 2012, Spruyt and Gozal wrote, “the most forgotten, overlooked, or even actively ignored behavior of this century is undoubtedly childhood sleep” (p. 38).⁴⁶ Findings from this review shed light on this claim; from the time of the first systematic reviews of childhood obesity published in 2008,^{10,12–14} leading up to 2015, fewer than 20% of family-based interventions to prevent child obesity promoted sleep. In contrast, 60%–90% of interventions targeted diet, physical activity, and/or media use.

Provided that no studies exclusively targeted sleep, only two intended to independently test the effect of sleep promotion on childhood obesity, which had a separate study arm for promoting sleep using a 2×2 factorial study design. Of those two studies, Paul et al.³⁴ found that children 2–5 years of age recruited into the “Soothe/Sleep” arm of study gained weight significantly slower at 1 year, but this was not the case for the control group or the combination of “Soothe/Sleep,” and another study arm that focused on “Introduction of Solids.” They also found that among breastfed children, children in the “Soothe/Sleep” group showed significantly more nocturnal sleep compared to controls.

However, the second of these two studies that promoted sleep in a separate study arm has since only reported the impact of the intervention on diet-related behaviors, not sleep.⁴⁸ This suggests that while positive effects of sleep promotion are beginning to emerge, it is also occurring sporadically, and more evidence is necessary to examine the impact. Moreover, interventions promoting sleep are still limited to the United States and Nordic countries, and children 2–5 years of age in clinical or home-based settings, so generalizable evidence for effectiveness of sleep promotion in family-based childhood obesity interventions is likely still to come.

Sleep promotion was rarely a focal intervention activity and in most instances was promoted in reference to other energy-balance behaviors. The coupling of sleep and other energy-balance behaviors is supported by a review by Yoong et al.,¹⁵ who found that interventions targeting sleep

may also have a positive impact on children's other energy-balance behaviors, like diet and physical activity.

Most studies did not measure parent sleep, some did not measure child sleep, and many relied on nonvalidated self-report measures of sleep. Less than a third used an objective measure of sleep such as actigraphy. Sleep measurement overwhelmingly focused on sleep duration; all 15 interventions that relied on self-report measured sleep duration and 3 had it as their only sleep measure. This collectively illustrates that sleep promotion was not a prime target in the family interventions reviewed.

This study is the first to operationalize the inclusion of sleep into family interventions to prevent obesity in children. Mounting evidence suggests that insufficient sleep is a risk factor for obesity^{10–15} and parents serve as fundamental agents of change in childhood obesity prevention.^{5,17} Additional strengths of this study include the combination of quantitative and qualitative data and reserving eligible interventions to only those that were explicit about promoting sleep.

However, a number of limitations need to be considered. First, this study is built on and constrained by a prior systematic review. However, this should not overshadow the rigor of our methods; by avoiding sleep-related search terms, we screened over 9000 articles that also lent to a comprehensive pool of interventions in our review.

Furthermore, given its adherence to PRISMA reporting guidelines, designed to ensure the rigor and transparency of systematic reviews, we do not anticipate that the original review threatens the validity of this study. More relevant results from this study may be limited by the clarity of reporting on sleep promotion activities and measures in publications. We were able to rectify most ambiguities through correspondence with study authors.

An emphasis on family-based interventions likely also skewed literature to that which included younger children; as the field grows, future reviews of the literature should assess the landscape of sleep promotion through a child developmental lens. Furthermore, our inclusion criteria (*i.e.*, childhood obesity prevention) may have limited the interventions in this study to those that reported measuring child weight-related outcomes, and hence studies that prioritized biomedical and quantitative methods. Studies that promote sleep with qualitative evaluation schemes may offer greater context to future reviews.

Finally, we avoided presenting data on study effectiveness. Provided the field of child sleep promotion is a growing one—and hence the wide variation in study characteristics would make it less meaningful to judge impact of sleep promotion, let alone for the few 13 studies that reported any results, and 11 of which were not designed with causal inference for sleep promotion in mind—our goal was rather to offer a snapshot of this phenomenon by focusing on sleep promotion's prevalence and context in family-based childhood obesity interventions. We hope our findings come of use to academics seeking to integrate or fund sleep promotion in future research.

This review indicates that sleep has received limited attention as an intervention target compared with other energy-balance behaviors in family-based interventions to prevent obesity in children. Moreover, interventions that integrate sleep are generally limited to infants and preschool-aged children in high-income countries.

Future interventions should allow more room for sleep promotion strategies and couple them with appropriate measures. Provided that this field is relatively new, whenever possible, studies are encouraged to explicitly report and consistently use designs, strategies, and measures that can be compared across one another. Such studies would especially benefit from using validated or objective measures of sleep behaviors, as well as including a separate study arm to promote sleep to examine the independent effectiveness of sleep promotion. This should be coupled with emerging research on the mechanisms by which sleep is associated with obesity, whether directly, by way of routines, or by other energy-balance behaviors.

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