Original Article

A longitudinal investigation of sleep hygiene as a mediator linking parental warmth with adolescent sleep

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Abstract

Study Objectives: Parental warmth in adolescence protects sleep in early adulthood, yet the nature, directions, and mechanisms of this association across adolescence are unknown. This study examined parental warmth, adolescent sleep hygiene and sleep outcomes (morning/eveningness, school night sleep duration, and daytime sleepiness) across five annual waves, spanning four years, using a cross-lagged panel design.
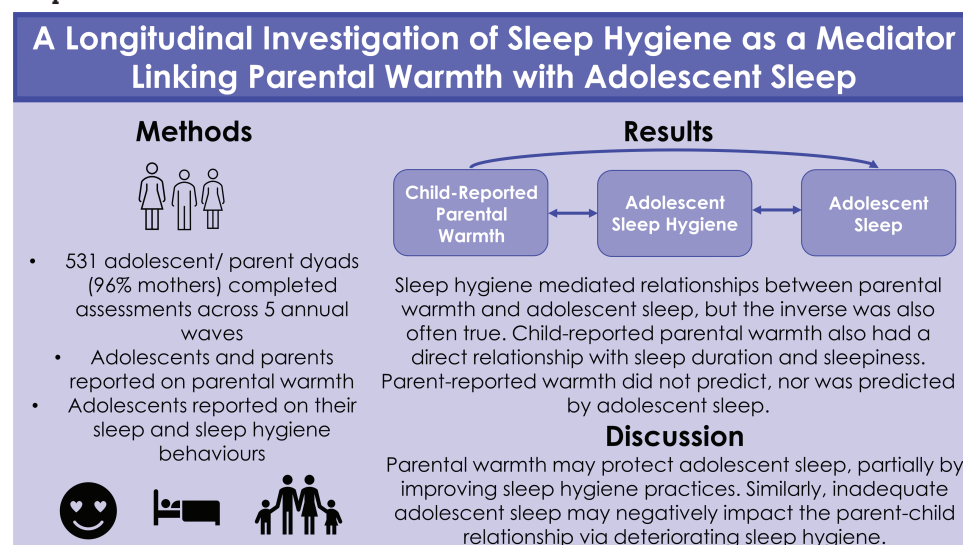
Methods: Adolescents and one primary caregiver (96% mothers) completed questionnaires assessing parental warmth (child- and parent-report) and adolescent sleep hygiene and sleep (child-report), across five annual waves: Wave 1 (N = 531, M_{age} = 11.18, SD = 0.56, 51% male), Wave 2 (N = 504, M_{age} = 12.19, SD = 0.53, 52% male), Wave 3 (N = 478, M_{age} = 13.19, SD = 0.53, 52% male), Wave 4 (N = 440, M_{age} = 14.76, SD = 0.47, 51% male), and Wave 5 (N = 422, M_{age} = 15.75, SD = 0.49, 51% male).

Results: Greater child-reported parental warmth was indirectly associated with better adolescent sleep (greater morningness, longer school night sleep duration, less sleepiness) through healthier sleep hygiene. The inverse was also often observed. Warmth had a direct relationship with sleep duration and sleepiness, independent of sleep hygiene. Parent-reported parental warmth did not predict, nor was predicted by child-reported adolescent sleep.

Conclusions: Parental warmth may protect against developmental changes in adolescent sleep, partially by improving sleep hygiene practices. Similarly, inadequate adolescent sleep may negatively impact parental warmth via deteriorating sleep hygiene. Sleep hygiene emerged as a key mechanism for protecting adolescent sleep and parent-child relationships.

Key words: morning/eveningness preference; sleep duration; sleepiness; parenting style; risk/protective factor

Graphical Abstract

A Longitudinal Investigation of Sleep Hygiene as a Mediator Linking Parental Warmth with Adolescent Sleep

Methods

- 531 adolescent/ parent dyads (96% mothers) completed assessments across 5 annual waves
- Adolescents and parents reported on parental warmth
- Adolescents reported on their sleep and sleep hygiene behaviours

Results

Child-Reported Parental Warmth → Adolescent Sleep Hygiene → Adolescent Sleep

Sleep hygiene mediated relationships between parental warmth and adolescent sleep, but the inverse was also often true. Child-reported parental warmth also had a direct relationship with sleep duration and sleepiness. Parent-reported warmth did not predict, nor was predicted by adolescent sleep.

Discussion

Parental warmth may protect adolescent sleep, partially by improving sleep hygiene practices. Similarly, inadequate adolescent sleep may negatively impact the parent-child relationship via deteriorating sleep hygiene.

Statement of Significance

Parental warmth in adolescence protects sleep in early adulthood, yet the nature, directions, and mechanisms of this association across adolescence are currently unknown. This study was the first to investigate longitudinal and bi-directional associations between parental warmth and adolescent sleep outcomes (morning/eveningness, school night sleep duration, and daytime sleepiness) across the course of adolescence; with sleep hygiene practices explored as a possible mediator of this relationship. Results indicated that parental warmth is indirectly associated with better adolescent sleep through healthier sleep hygiene practices. However, the inverse was also largely true. Therefore, sleep hygiene emerged as a key mechanism that should be targeted to protect adolescent sleep and parent–child relationships.

Introduction

Adolescents develop an increasingly evening diurnal preference (i.e. the preference for completing activities, such as eating, study, exercise, in the evening), from late childhood, peaking in early adulthood [1]. Though increasing eveningness is partly driven by normative delays in circadian timing, eveningness is also driven by social and societal factors (e.g. school, work, extracurricular activities etc.) [2]. When paired with early school start times, eveningness contributes to truncated sleep duration and daytime sequalae such as excessive sleepiness [3]. More than half of adolescents obtain insufficient sleep (<8 hr) on school nights [4], with correlates including impaired physical health (e.g. overweight/obesity, pain, cardiometabolic impairment), worse psychosocial wellbeing (e.g. poor mental health, low self-esteem), poorer academic outcomes, and increased risk-taking behavior [5]. As such, it is a priority to identify modifiable risk and protective factors that can be leveraged to reduce the incidence and burden of inadequate sleep in this vulnerable population.

Parents are ideally placed, and highly motivated, to optimize adolescent sleep. A recent review and meta-analysis identified a number of parent-related factors (e.g. rule setting, parents' own sleep and related behaviors, family functioning) that support better adolescent sleep and daytime functioning [6]. Parental warmth (i.e. showing positive regard, such as love and care through interactions, involvement and affirmations) was one of the parenting factors with the most consistent (i.e. convergent) empirical support [6]. Although effect sizes are small, parental warmth has been cross-sectionally associated with morningness and earlier sleep timing [7–11] and longer subjectively reported sleep duration [6, 12–14]. However, the pooled effect size for objectively measured sleep duration has been found to be negligible and nonsignificant [6].

In one large (*N* = 5419) national (USA) survey, authoritative parenting (i.e. a parenting style characterized by high emotional warmth and responsiveness, and limit setting), when paired with family routine at age 12–14, predicted longer subjective sleep duration ten years later [15]. There is also a moderate cross-sectional association between parental warmth and lower daytime dysfunction [6], with another large (*N* = 14 493) nationally-representative (USA) longitudinal study showing that greater maternal care and support at 16 years of age predicted less daytime sleepiness at age 22 [16]. In sum, parental warmth shows a robust, small-to-medium, association with greater morningness, longer sleep duration and less daytime sleepiness, with two longitudinal studies also demonstrating that parental warmth predicts longer sleep duration and less daytime sleepiness, five to 10 years later.

Whilst there is increasing evidence for the protective role of parental warmth for adolescent sleep, longitudinal studies are rare and have not i) measured multiple aspects of sleep, nor in adolescence, ii) measured parental warmth via child- *and*

parent-report separately, iii) assessed the possibility of bidirectional associations, or iv) tested mechanisms of the association. Longitudinal studies to date have not had an explicit focus on sleep (i.e. sleep was a secondary outcome), thus only one aspect of sleep was measured (i.e. sleep duration or sleepiness), each by a single item [15, 16]. These studies had a lengthy time lag (5–10 years), and follow-ups have only occurred in early adulthood (22–24 years) [15, 16]. Earlier levels of adolescent sleep were not controlled for, therefore, results essentially indicate an association between parental warmth and sleep, without demonstrating that parental warmth predicts *changes* in sleep longitudinally (as cross-lagged panel designs allow). As such, the nature of the relationship between parental warmth and sleep across adolescence is unknown.

Furthermore, only five of the thirty-one studies investigating the relationship between parental warmth and adolescent sleep have used nonadolescent reports of parenting behavior [6]. Parents and adolescents are likely to report quite different perspectives on parenting, and the predictive ability of both child- and parent-reported parental warmth is currently unknown in the adolescent sleep field. Thus, a multi-informant approach would allow for a more nuanced understanding of the associations between these constructs. Consequently, the first aim of the present study was to examine longitudinal associations between parental warmth (child- and parent-reported) and adolescent sleep (child-reported eveningness preference, school night sleep duration and daytime sleepiness) from pre- to mid-adolescence, using a cross-lagged panel design.

Although there is preliminary evidence that parental warmth longitudinally predicts better early adult sleep, no studies have looked at the impact of parental warmth on adolescent sleep during adolescence, and the inverse relationship has not been explored. Parent–child interactions are dynamic, therefore it is also possible that better adolescent sleep predicts a warmer parent–child relationship. For example, normative shifts toward eveningness may lead to more conflict over bedtimes and morning routines [17, 18], which may adversely affect the parent–child relationship and thus, parental warmth. Sleep restriction (i.e. reduced sleep duration) and daytime sleepiness increase emotional reactivity [19], which may also lead to parent–child conflict and reduced parental warmth. Indeed, parents of evening-type adolescents rate their child as more lazy, less trustworthy and more worrisome, compared to parents of intermediate and morning types [20]. As no studies have tested the possibility of bidirectionality between parental warmth and adolescent sleep, this was an exploratory aim of the current study.

Another important gap in the literature is the lack of knowledge regarding the mechanisms underpinning the relationship between parental warmth and adolescent sleep [6]. A conceptual model has proposed that the parent–child relationship is directly

and indirectly related to child sleep, through child self-regulation [21]. Specifically, the model suggests that a balance of parental warmth and responsiveness, and limit setting, may directly promote better child sleep [21]. In addition, parental warmth may support the child's capacity to self-regulate their emotions and behaviors, which has flow on benefits for child sleep [21]. However, this model needs testing.

Self-regulation (i.e. the ability to understand and manage one's own emotions and behaviors) can be operationalized in a variety of ways. Since emotions and behaviors proximal to sleep are likely to have the strongest effect on adolescent sleep quality, duration and timing, relative to other times of the day, sleep hygiene practices are of interest to the current study. Sleep hygiene refers to self-regulatory practices that promote physiological, behavioral and emotional preparedness for sleep (e.g. a bedtime routine, minimizing screen time and food/drink before bedtime, and trying to regulate emotions prior to bedtime). It has been proposed that a positive parent–child relationship may encourage adolescents to engage in healthier sleep practices [14, 22]. As indirect support of this model, there is cross-sectional evidence showing that sleep hygiene practices mediate the relationship between family disorganization and adolescent sleep duration and daytime sleepiness [23]; however, this pathway is yet to be examined longitudinally. As such, the second aim of the current study was to prospectively examine whether healthier adolescent sleep hygiene practices mediate the relationship between parental warmth and better adolescent sleep (i.e. morningness, longer sleep duration, less daytime sleepiness).

The current study examined the longitudinal associations between child- and parent-reported parental warmth, and child-reported adolescent sleep hygiene practices and sleep (morning/eveningness, school night sleep duration, and daytime sleepiness) across five annual waves of data collection. It was hypothesized that parental warmth would predict better adolescent sleep (greater morningness, longer sleep duration, less daytime sleepiness) over time, and that this relationship would be mediated by healthier adolescent sleep hygiene practices. Given the second aim of this study was exploratory, there was no explicit hypothesis regarding the relationship from adolescent sleep to later parental warmth, either directly or indirectly via sleep hygiene.

Methods

Participants

A total of 531 (adolescent M_{age} = 11.18, SD = 0.56, range = 10–12, 51% male) pre-adolescents and one of their parents/ primary caregivers (96% mothers, 3% fathers, 0.2% sister, 0.6% other; parent M_{age} = 44.21, SD = 4.46, range = 20–60) commenced the study in Wave 1. Of these, 504 (adolescent M_{age} = 12.19, SD = 0.53, 52% male) child–parent dyads completed relevant measures again in Wave 2, 478 (adolescent M_{age} = 13.19, SD = 0.53, 52% male) in Wave 3, 440 (adolescent M_{age} = 14.76, SD = 0.47, 52% male) in Wave 4 and 422 (adolescent M_{age} = 15.75, SD = 0.49, 51% male) in Wave 5. Each wave of data collection was approximately one year apart. Approximately 90% of participants were born in Australia, with 82% reporting having a white background. Approximately 21% of parents reported a gross household income under $100,000AUD, 44% reported a household income between $100,000–200,000AUD and 34% reported a household income greater than $200,000AUD. Most parents had an undergraduate (37%) or postgraduate (34%) university degree, and most (70%) had never been diagnosed with

a mental health disorder. Participants were recruited from the general public, via advertisements placed in schools, childcare centers, sporting clubs, medical centers and on local community Facebook pages in Sydney, Australia.

Procedures

The current study was part of the larger Risks to Adolescent Wellbeing (RAW) Project, which was approved by the Macquarie University Human Research Ethics Committee. Informed consent was obtained from all parents and assent was obtained from adolescents. As part of the larger study protocol, at each wave of data collection, adolescents and parents completed an online questionnaire via the survey platform Qualtrics (Qualtrics, Provo, UT). Amongst other psychological constructs, the questionnaire assessed parenting style, sleep hygiene behaviors, morningness/ eveningness preference, school night sleep duration and daytime sleepiness.

Measures

Parenting Style

Parental warmth was assessed through parent- and child-report versions of the Egna Minnen Beträffande Uppfostran Child-Report (EMBU-P/C) [24, 25]. The EMBU-C includes 40 items assessing emotional warmth, rejection overprotection and anxious rearing however only 6-items from the emotional warmth subscale were used in the current study (e.g. "*Your parents want to be with you*"). Items were rated on a 4-point scale (1 = "*No, never*", 4 = "*Yes, most of the time*"). A total item score for the subscale was calculated (range 6–24), with higher scores indicating greater parental emotional warmth. Reliability of the warmth subscale was acceptable (Child-report: Wave 1: α = 0.77; Wave 2: α = 0.84; Wave 3: α = 0.84, Wave 4: α = 0.86, Wave 5: α = 0.86; Parent-report: Wave 1: α = 0.71; Wave 2: α = 0.74; Wave 3: α = 0.74, Wave 4: α = 0.72, Wave 5: α = 0.71), in line with past research (α = 0.77) [26].

Adolescent sleep hygiene

Adolescent sleep hygiene practices were assessed using the Adolescent Sleep Hygiene Scale [ASHS [27]]. The 28-item child-report ASHS yields 8 subscales, however only items relating to the physiological (5 items; e.g. "*During the 1 hour before bedtime, I am very active (e.g. playing outside, running, wrestling)*"), behavioral arousal (3 items; e.g. "*I go to bed and do things in my bed that keep me awake (e.g. watching TV, reading)*"), cognitive/emotional (6 items; e.g. "*During the 1 hour before bedtime, things happen that make me feel strong emotions (e.g. sadness, anger, excitement)*"), sleep environment (5 items; e.g. "*I fall asleep while listening to loud music*") and bedtime routine (1 item; (e.g. "*I use a bedtime routine (e.g. bathing, brushing teeth, reading)*") subscales were administered in the current study. Items are rated on a 6-point scale (1 = "*Never*", 6 = "*Always*"). Subscale scores were generated by averaging relevant items, and the total ASHS score was derived by averaging each subscale score. Therefore, all scores range from 1 to 6, with higher scores indicating healthier sleep hygiene practices. Reliability of the total scale was acceptable (Wave 1: α = 0.76; Wave 2: α = 0.78; Wave 3: α = 0.81, Wave 4: α = 0.82, Wave 5: α = 0.82), in line with past research (α = 0.80) [28].

Morning/eveningness preference

Adolescent self-reported diurnal preference was measured using the 10 item Children's Morningness-Eveningness Scale [MESC [29]]. The response scale varies by item (e.g. "*Is it easy for you to get up in the morning?*"; 1 = "*No way!*", 2 = "*Sort of*", 3 = "*Pretty easy*",
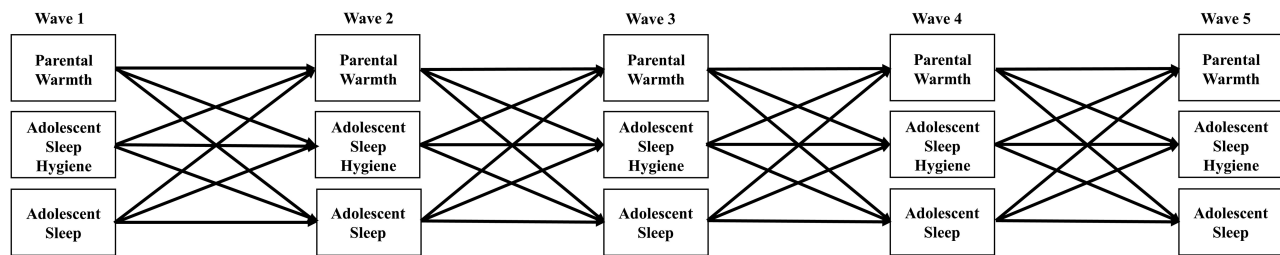
Figure 1. Schematic illustrating the autoregressive and cross-lagged paths specified in each statistical model. To avoid visual overcrowding concurrent associations between variables within each wave and covariates (child gender, household income, parental/ caregiver education and parental/ caregiver mental health) are not depicted in the figure. However, these were specified in each model.

4 = *"It's a cinch (really easy)"*). Total scores range from 10 to 43, with lower scores indicative of evening preference and higher scores indicative of morningness. Total scores from 10 to 20 indicate evening diurnal preference, 21 to 27 intermediate diurnal preference and 28 to 43 morning diurnal preference. Reliability of the morningness-eveningness scale was acceptable (Wave 1: α = 0.79; Wave 2: α = 0.81; Wave 3: α = 0.83; Wave 4: α = 0.83; Wave 5: α = 0.85) in line with past research (α = 0.73) [30].

School night sleep duration
Adolescent school night sleep duration was assessed by child-report using a single item (e.g. *How many hours sleep do you usually get each night on a school night?*).

Daytime sleepiness
Daytime sleepiness was measured using the 8-item child-reported Pediatric Daytime Sleepiness Scale (PDSS) [31]. Items (e.g. *"How often do you fall asleep or feel drowsy in class?"*) are answered on a 5-point scale (0 = *"Never"* to 4 = *"Always"*). Items are summed to create a total score that ranges from 0 to 32, with higher scores indicating greater daytime sleepiness. Reliability of the PDSS was acceptable at all waves (Wave 1: α = 0.78; Wave 2: α = 0.81; Wave 3: α = 0.83; Wave 4: α = 0.86; Wave 5: α = 0.87), consistent with past research (α = 0.80) [31].

Covariates
To control for other factors that may account for the relationship between parental warmth and adolescent sleep, parents/caregivers reported on socio-economic status (household income; *"What is the approximate gross household yearly income (in AUD) in your child's primary residence?"*), parental/caregiver education (*"What is your highest level of education?"*) and parental/ caregiver mental health (*"Have you previously been diagnosed with an anxiety or depressive disorder or other type of mental illness?"*).

Statistical analysis
Data aggregation and preliminary descriptive statistics were undertaken using SPSS, version 27.0 (IBM Corporation, Armonk NY, USA). Linear mixed models were used to assess for change in variables over time, and associations between key variables were first explored through Pearson correlations. Longitudinal cross-lagged panel analyses were undertaken with MPlus version 8.5 [32]. Separate models were specified for each sleep related outcome (morningness/eveningness, school night sleep duration, daytime sleepiness), and for child- and parent-reported parental warmth, separately (see Figure 1 for schematic representation of each model). Parent- and child-reported models were run separately because parent- and child-reported parental warmth

were only modestly correlated within each wave (r = .20–.39). Furthermore, examining each sleep-related outcome separately provides a more nuanced investigation into the relationship between parental warmth and adolescent sleep (i.e. compared to creating a latent "sleep" variable). In all models, autoregressive paths (i.e. controlling for levels at each prior wave) and cross-lagged paths between parental warmth, sleep hygiene and sleep variables were specified. Concurrent associations between variables within each wave were also specified (i.e. via correlating the residuals). As recommended by Orth and colleagues [33], equality constraints were placed on all autoregressive and cross-lagged paths over time. In all models, child gender, household income, parental/caregiver education and parental/ caregiver mental health were controlled for, with covariates predicting each observed variable in the model, at all timepoints.[1] Standardized beta coefficients are reported to allow for comparisons of the relative strength of longitudinal relationships. If significant direct paths emerged between parental warmth, sleep hygiene and adolescent sleep, then the relevant mediation paths were subsequently tested. Orth and colleagues [34] suggest the following cut-off values for interpreting small (0.03), medium (0.07), and large (0.12) effects in cross-lagged panel models, respectively. Correlation coefficients were interpreted with the following cut off values for small (0.10), medium (0.30), and large (0.50) effects; and cohen's *d* with the following cut off values for small (0.20), medium (0.50), and large (0.80) effects.

Missing data in SPSS were handled with linear mixed models, which use expectation maximization to impute missing values based on a regression line for each individual. Missing data in MPlus were handled using full information maximum likelihood estimation (FIML). The ML standard maximum likelihood estimator, with 5000 bootstraps, was used to estimate cross-lagged and mediation analyses. Given the large number of comparisons in the current paper, significance levels were adjusted to account for a paper-wide 5% false discovery rate using the Benjamini–Hochberg procedure [35]. The revised critical alpha level was *p* < .031.

Results
Preliminary analyses
Descriptive statistics and results from linear mixed models relating to parental warmth, adolescent sleep hygiene practices and sleep are presented in Table 1 (see Figures in Supplement Figure S1), and correlation coefficients are presented in Table 2. Child- and parent-reported parental warmth were significantly

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[1]Gender moderation was also explored for child-reported models (the only models where parental warmth was longitudinally related to adolescent sleep), with no evidence of moderation.

Table 1. *Descriptive statistics (Estimates Marginal Means, Standard Errors, Range) for parental warmth, sleep hygiene and sleep variables from Wave 1 to Wave 5, and inferential statistics for linear mixed models, testing changes in variables over time.*

		Wave 1 Mean (SE) Range	Wave 2 Mean (SE) Range	Wave 3 Mean (SE) Range	Wave 4 Mean (SE) Range	Wave 5 Mean (SE) Range	F	p	W1/W2	W2/W3	d W3/W4	W4/W5
Parental Warmth	Child-reported Parental Warmth	20.39 (0.13) 8–24	19.72 (0.15) 6–24	19.14 (0.15) 6–24	18.61 (0.17) 6–24	17.92 (0.17) 6–24	49.07	<.001	0.21	0.17	0.15	0.18
	Parent-reported Parental Warmth	21.03 (0.10) 13–24	20.51 (0.11) 12–24	20.28 (0.11) 12–24	20.00 (0.12) 12–24	19.66 (0.12) 12–24	40.51	<.001	0.22	0.09	0.10	0.12
Sleep	Sleep Hygiene	4.71 (0.03) 2.75–5.93	4.78 (0.03) 2.56–6.00	4.73 (0.03) 2.53–5.96	4.64 (0.03) 2.74–5.89	4.49 (0.03) 2.91–5.80	24.90	<.001	0.11	0.08	0.15	0.22
	Morningness/ Eveningness	31.39 (0.22) 14–43	30.84 (0.23) 13–43	29.67 (0.24) 12–42	28.03 (0.26) 14–41	26.86 (0.27) 11–40	74.73	<.001	0.11	0.22	0.28	0.19
	School Night Sleep Duration	9.29 (0.05) 3–12	8.84 (0.05) 4–12	8.43 (0.05) 3–11	7.98 (0.06) 3–11	7.65 (0.05) 4–11	145.24	<.001	0.38	0.35	0.36	0.26
	Daytime Sleepiness	10.95 (0.25) 0–28	10.91 (0.26) 0–30	11.76 (0.28) 0–31	12.38 (0.30) 0–32	13.75 (0.32) 0–32	22.08	<.001	0.006	0.14	0.09	0.19
M/E Preference Category (%)		M/I/E 79/19/2	M/I/E 75/22/3	M/I/E 66/29/5	M/I/E 54/38/8	M/I/E 49/36/15						

Note: M/E= Morningness/ Eveningness, M= Morning type, I= Intermediate type, E= Evening Type. Adjusted significance levels = p≤.030.

positively correlated within each wave, with small effects observed. Adolescent sleep hygiene and sleep variables were all significantly correlated in the expected direction within each wave, with small to moderate effects observed. Child-reported parental warmth had small statistically significant intra-wave correlations with sleep hygiene, and all sleep variables, within every wave. That is, greater child-reported parental warmth was associated with healthier adolescent sleep hygiene practices, greater morningness preference, longer sleep duration and less daytime sleepiness. Parent-reported parental warmth was not significantly associated with sleep hygiene or sleep variables in wave 1. Small positive and negative correlations emerged with sleep hygiene and daytime sleepiness in wave 2, respectively. Parent-reported parental warmth was significantly positively correlated with sleep hygiene, morningness, and sleep duration, and negatively correlated with daytime sleepiness within waves 3 and 4, with small effects observed. However, in wave 5, intra-wave correlations with sleep hygiene and all sleep variables were nonsignificant.

Linear mixed models revealed a significant main effect of time for all key variables. Both child- and parent-reported parental warmth decreased over time and adolescent sleep hygiene practices worsened over time. As shown in Table 1, there was a shift towards evening diurnal preference. Only two percent of participants were evening-type in wave 1, and this increased to fifteen percent in wave 5. Correspondingly, school night sleep duration decreased over time, and daytime sleepiness increased. Effect sizes (*d*) were all small, but largest for changes in sleep duration, followed by the shift from morningness to eveningness preference.

Cross-lagged models

Morningness/eveningness preference

Figure 2a depicts the statistically significant paths in the model investigating the relationship between child-reported parental warmth, adolescent sleep hygiene and adolescent morningness/eveningness preference (Model Fit: X^2 (N = 494) = 88.90, *df* =63, CFI = 0.99, RMSEA = 0.029). Table S1 provides standardised beta coefficients for all autoregressive and cross-lagged paths

in the model. Across all waves, greater child-reported parental warmth predicted healthier sleep hygiene, which in turn predicted greater morningness diurnal preference. However, greater morningness preference also predicted healthier sleep hygiene, which in turn predicted greater child-reported parental warmth. The indirect path from parental warmth to morningness/eveningness preference was fully mediated by sleep hygiene from Wave 1 to Wave 3 (β = .006, SE = .002, *p* = .007), Wave 2 to Wave 4 (β = .006, SE = .002, *p* = .007) and from Wave 3 to Wave 5 (β = .006, SE = .002, *p* = .007). Inversely, the indirect path from morningness/eveningness preference to parental warmth was fully mediated by sleep hygiene from Wave 1 to Wave 3 (β = .005, SE = .002, *p* = .017), Wave 2 to Wave 4 (β = .005, SE = .002, *p* = .018) and from Wave 3 to Wave 5 (β = .005, SE = .002, *p* = .019).

Figure 2b depicts the statistically significant paths in the model investigating the relationship between parent-reported parental warmth, and child-reported adolescent sleep hygiene and adolescent morningness/eveningness preference (Model Fit: X^2 (N = 494) = 95.14, *df* =63, CFI = 0.99, RMSEA = 0.032). Table S2 provides standardized beta coefficients for all autoregressive and cross-lagged paths in the model. Across all waves, healthier sleep hygiene practices predicted greater morningness diurnal preference, and vice versa. However, parental warmth did not predict sleep hygiene, or morningness/eveningness over time, and morningness/eveningness and sleep hygiene did not predict parental warmth.

School night sleep duration

Figure 3a depicts the statistically significant paths in the model investigating the relationship between child-reported parental warmth, adolescent sleep hygiene and adolescent school night sleep duration (Model Fit: X^2 (N = 494) = 82.82, *df* = 63, CFI = 0.99, RMSEA = 0.025). Table S3 provides standardized beta coefficients for all autoregressive and cross-lagged paths in the model. Across all waves, greater child-reported parental warmth predicted healthier sleep hygiene, which in turn predicted longer school night sleep durations. Greater parental warmth also directly predicted longer school night sleep durations. Longer school night sleep durations also predicted healthier sleep hygiene, which in

Table 2. *Correlations between parental warmth, sleep hygiene and adolescent sleep from Wave 1 to Wave 5.*

| | | Wave 1 | | | | | | Wave 2 | | | | | | Wave 3 | |
| | | Warmth | | Sleep | | | | Warmth | | Sleep | | | | Warmth | |
		C–R	P-R	SH	M/E	SD	DS	C-R	P-R	SH	M/E	SD	DS	C-R	P-R
Wave 1	C-R	-	.20	.25	.25	.22	-.20	.509	.17	.24	.17	.13	-.12	.44	.18
	P-R		-	.07	-.007	.09	-.03	.25	.53	.07	.05	.01	-.05	.24	.53
	SH			-	.33	.30	-.44	.28	.11	.48	.26	.17	-.29	.23	.12
	M/E				-	.28	-.64	.21	.08	.23	.66	.23	-.44	.13	.09
	SD					-	-.27	.19	.03	.25	.27	.43	-.24	.14	.002
	DS						-	-.18	-.05	-.33	-.45	-.18	.54	-.08	-.04
Wave 2	C-R							-	.27	.34	.28	.25	-.22	.57	.29
	P-R								-	.10	.09	.08	-.11	.30	.61
	SH									-	.34	.26	-.47	.24	.12
	M/E										-	.28	-.62	.21	.10
	SD											-	-.29	.13	-.02
	DS												-	-.15	-.10
Wave 3	C-R													-	.39
	P-R														-
	SH														
	M/E														
	SD														
	DS														
Wave 4	C-R														
	P-R														
	SH														
	M/E														
	SD														
	DS														
Wave 5	C-R														
	P-R														
	SH														
	M/E														
	SD														
	DS														

Adjusted significance levels = p≤.030. Correlation coefficients in bold are statistically significant at or below the adjusted *p* value. C-R= child-reported, P-R= parent-reported, SH= sleep hygiene, M/E= morningness/ eveningness, SD= sleep duration, DS= daytime sleepiness.

turn predicted greater child-reported parental warmth. That is, with the exception of the path from school night sleep duration to parental warmth, all paths in the model were significant. The indirect path from parental warmth to school night sleep duration was partially mediated by sleep hygiene from Wave 1 to Wave 3 (β = .010, SE = .004, *p* = .006), Wave 2 to Wave 4 (β = .009, SE = .003, *p* = .005) and from Wave 3 to Wave 5 (β = .010, SE = .004, *p* = .006). Inversely, the indirect path from school night sleep duration to parental warmth was not significantly mediated by sleep hygiene from Wave 1 to Wave 3 (β = .005, SE = .002, *p* = .036), Wave 2 to Wave 4 (β = .005, SE = .002, *p* = .038) or from Wave 3 to Wave 5 (β = .004, SE = .002, *p* = .040).

Figure 3b depicts the statistically significant paths in the model investigating the relationship between parent-reported parental warmth, and child-reported adolescent sleep hygiene and adolescent school night sleep duration (Model Fit: X^2 (*N* = 494) = 95.79, *df* = 63, CFI = 0.99, RMSEA = 0.032). Table S4 provides standardized beta coefficients for all autoregressive and cross-lagged paths.

Across all waves, healthier sleep hygiene practices predicted longer sleep duration, and vice versa. Healthier adolescent sleep hygiene practices also predicted greater parent-report parental warmth. However, parental warmth did not predict sleep hygiene, or sleep duration over time, and sleep duration did not predict parental warmth. The indirect path from school night sleep duration to parental warmth was not significantly mediated by sleep hygiene from Wave 1 to Wave 3 (β = .004, SE = .002, *p* = .073), Wave 2 to Wave 4 (β = .004, SE = .002, *p* = .074) and from Wave 3 to Wave 5 (β = .004, SE = .002, *p* = .074).

Daytime sleepiness

Figure 4a depicts the statistically significant paths in the model investigating the relationship between child-reported parental warmth, adolescent sleep hygiene and adolescent daytime sleepiness (Model Fit: X^2 (*N* = 494) = 91.04, *df* =63, CFI = 0.99, RMSEA = 0.030). Table S5 provides standardized beta coefficients for all autoregressive and cross-lagged paths in the model. Across all

|	Wave 4										Wave 5					
	Sleep				Warmth		Sleep				Warmth		Sleep			
	SH	M/E	SD	DS	C-R	P-R	SH	M/E	SD	DS	C-R	P-R	SH	M/E	SD	DS
	.24	.13	.13	-.14	.34	.16	.15	.11	.10	-.12	.34	.14	.19	.13	.13	-.10
	.08	.04	.11	-.08	.25	.50	.05	.07	.06	-.11	.22	.49	.09	.02	.07	-.05
	.46	.26	.23	-.28	.20	.10	.34	.28	.19	-.27	.12	.04	.34	.16	.13	-.17
	.27	.58	.18	-.36	.06	.03	.18	.51	.18	-.34	.07	-.02	.21	.41	.13	-.24
	.21	.21	.31	-.20	.06	.05	.18	.15	.27	-.16	-.03	-.02	.07	.08	.12	-.05
	-.31	-.44	-.19	.48	-.07	-.01	-.20	-.41	-.19	.42	-.03	.04	-.26	-.21	-.15	.32
	.30	.257	.22	-.25	.47	.25	.19	.19	.18	-.19	.36	.26	.17	.20	.21	-.12
	.14	.09	.12	-.10	.34	.60	.14	.17	.10	-.15	.23	.59	.11	.09	.10	-.12
	.55	.31	.29	-.40	.18	.12	.48	.27	.22	-.32	.19	.08	.39	.21	.15	-.26
	.25	.71	.25	-.45	.15	.08	.21	.59	.15	-.37	.08	.04	.22	.50	.13	-.33
	.14	.27	.45	-.21	.11	.03	.18	.21	.21	-.19	.01	-.02	.10	.17	.21	-.13
	-.28	-.50	-.24	.59	-.17	-.08	-.23	-.47	-.20	.54	-.12	-.02	-.30	-.38	-.16	.46
	.29	.24	.24	-.24	.62	.33	.30	.21	.18	-.25	.51	.30	.21	.19	.14	-.16
	.17	.10	.11	-.12	.36	.62	.12	.10	.14	-.13	.32	.65	.13	.05	.08	-.12
	-	.33	.35	-.46	.29	.13	.62	.35	.26	-.37	.26	.08	.55	.33	.27	-.38
		-	.33	-.62	.21	.06	.30	.72	.22	-.51	.08	.02	.32	.62	.17	-.41
			-	-.36	.18	.12	.34	.32	.47	-.29	.15	.08	.21	.30	.41	-.28
				-	-.25	-.13	-.40	-.52	-.28	.68	-.12	-.06	-.40	-.41	-.24	.53
					-	.34	.31	.30	.23	-.32	.62	.30	.28	.26	.21	-.28
						-	.13	.12	.17	-.16	.27	.61	.10	.04	.04	-.06
							-	.40	.33	-.42	.24	.07	.61	.36	.32	-.38
								-	.33	-.67	.15	.10	.40	.76	.29	-.54
									-	-.35	.18	.13	.30	.27	.51	-.29
										-	-.19	-.10	-.40	-.50	-.29	.67
											-	.31	.32	.22	.21	-.26
												-	.04	.06	.08	-.08
													-	.45	.37	-.54
														-	.38	-.64
															-	-.38
																-

waves, greater child-reported parental warmth predicted healthier sleep hygiene, which in turn predicted less daytime sleepiness. Greater parental warmth also directly predicted less sleepiness. However, lower sleepiness also predicted healthier sleep hygiene, which in turn predicted greater child-reported parental warmth. That is, with the exception of the path from daytime sleepiness to parental warmth all paths in the model were significant. The indirect path from parental warmth to daytime sleepiness was partially mediated by sleep hygiene from Wave 1 to Wave 3 (β = −.008, SE = .002, p = .001), Wave 2 to Wave 4 (β = −.008, SE = .003, p = .001) and from Wave 3 to Wave 5 (β = −.008, SE = .003, p = .001). Inversely, the indirect path from daytime sleepiness to parental warmth was fully mediated by sleep hygiene from Wave 1 to Wave 3 (β = −.005, SE = .002, p = .024), Wave 2 to Wave 4 (β = −.005, SE = .002, p = .024) and from Wave 3 to Wave 5 (β = −.005, SE = .002, p = .025).

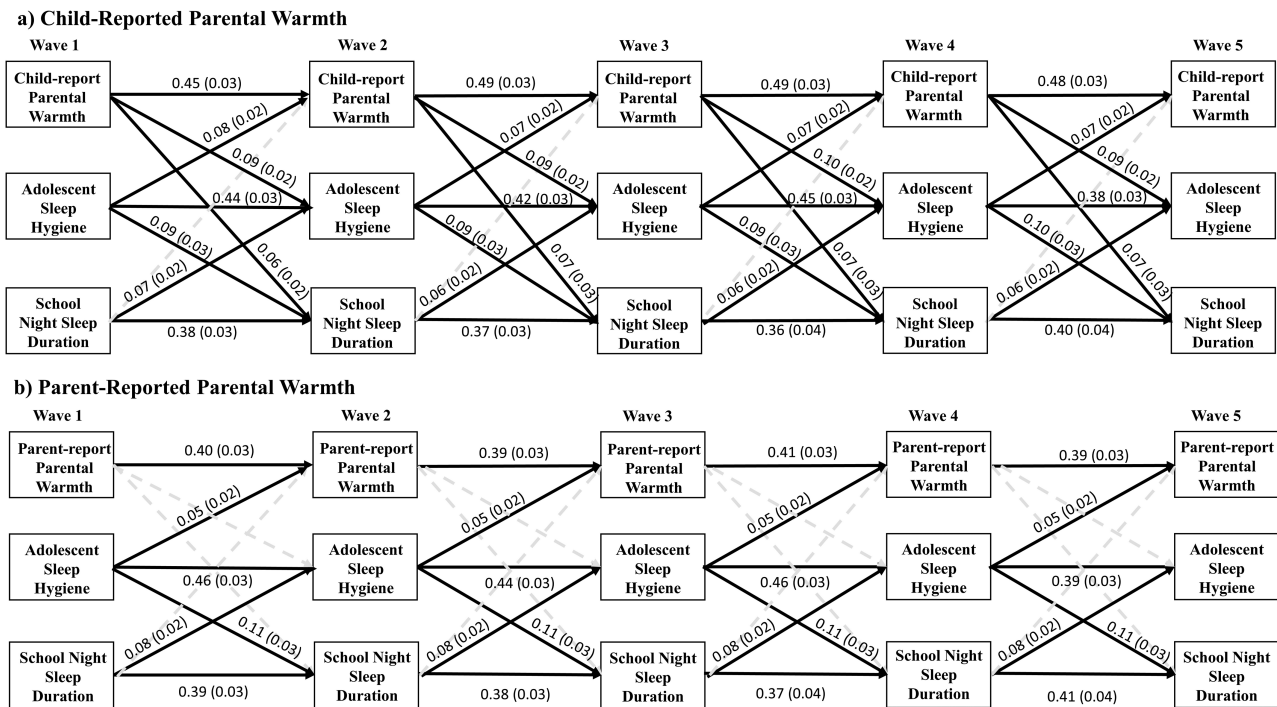Figure 4b depicts the statistically significant paths in the model investigating the relationship between parent-reported parental warmth, and child-reported adolescent sleep hygiene and adolescent daytime sleepiness (Model Fit: X^2 (N = 494) = 91.81, df = 63, CFI = 0.99, RMSEA = 0.030). Table S6. provides standardized beta coefficients for all autoregressive and cross-lagged paths. Across all waves, healthier sleep hygiene practices predicted lower daytime sleepiness, and vice versa. However, parental warmth did not predict sleep hygiene, or sleepiness over time, and sleepiness and sleep hygiene did not predict parental warmth.

Discussion

This study investigated the longitudinal and bidirectional, relationships between child- and parent-reported parental warmth and child-reported adolescent sleep (morning/eveningness, school night sleep duration, daytime sleepiness), over five annual waves. To shed light on mechanisms underpinning this association, adolescent sleep hygiene practices were explored as a potential mediating factor.
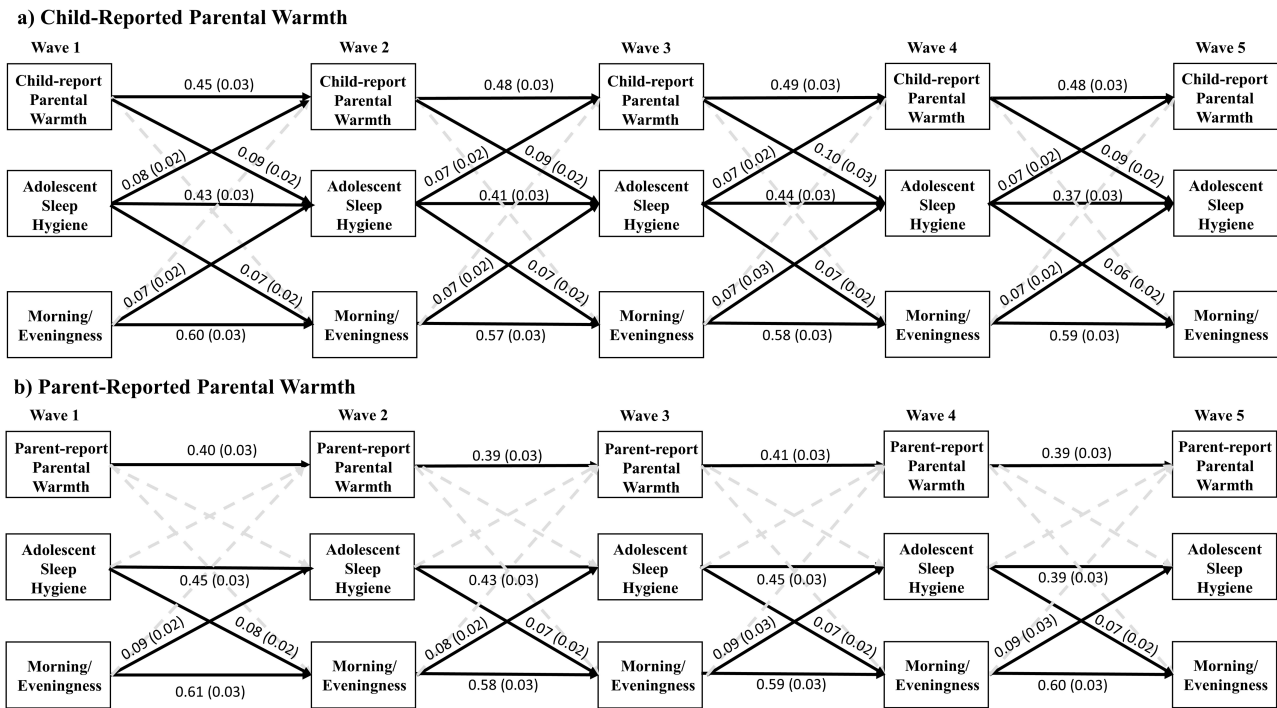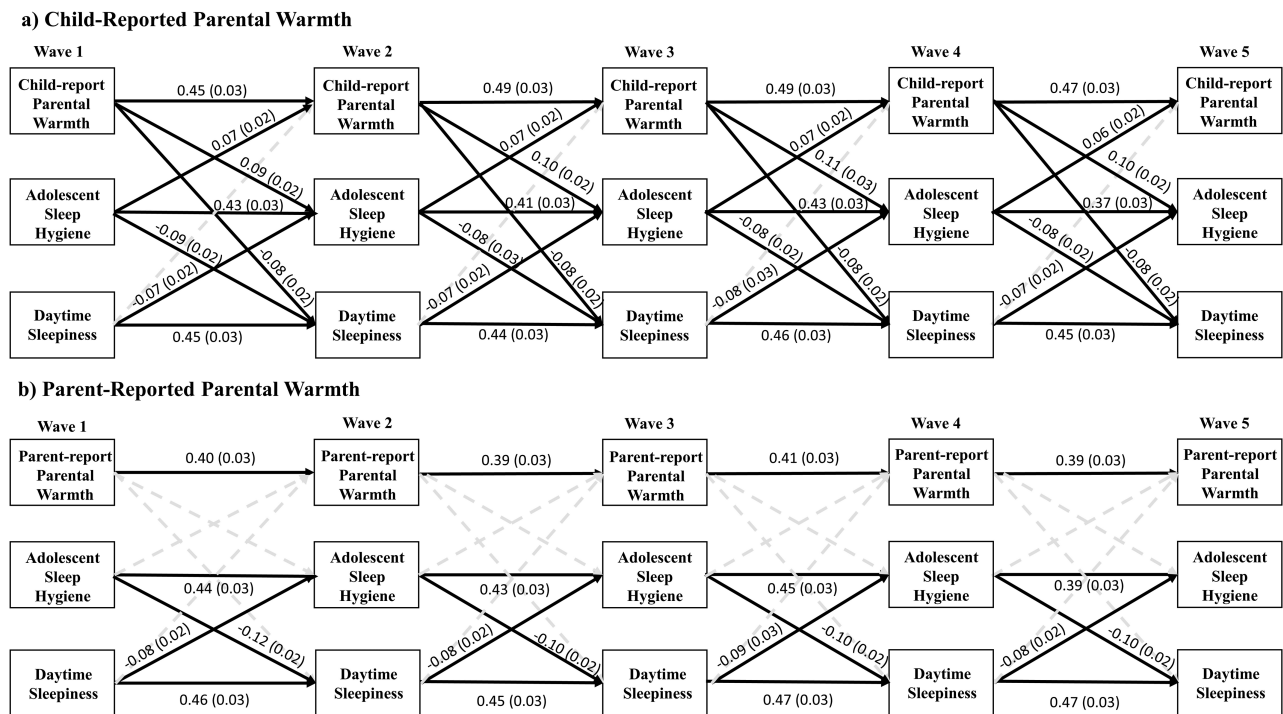
Figure 2. Schematic illustrating the statistically significant relationships between a) child-reported parental warmth, adolescent sleep hygiene and adolescent morningness/eveningness preference from Wave 1 to Wave 5 and b) parent-reported parental warmth, adolescent sleep hygiene and adolescent morningness/eveningness preference from Wave 1 to Wave 5. Solid lines = significant paths, dashed lines = non-significant paths. Standardised beta coefficients are presented with standard errors in parentheses.

Figure 3. Schematic illustrating the statistically significant relationships between a) child-reported parental warmth, adolescent sleep hygiene and adolescent school night sleep duration from Wave 1 to Wave 5 and b) parent-reported parental warmth, adolescent sleep hygiene and adolescent school night sleep duration from Wave 1 to Wave 5. Solid lines = significant paths, dashed lines = nonsignificant paths. Standardized beta coefficients are presented with standard errors in parentheses.

In support of results from a recent meta-analysis [6], child-reported parental warmth was cross-sectionally and longitudinally associated with longer school night sleep duration and less daytime sleepiness. The current results extend upon prior findings, by also showing a prospective relationship with greater morningness preference. Furthermore, the only two prior longitudinal studies included in the meta-analysis had lengthy (5 and 10 year) follow-ups, in early adulthood, and results from the current study

a) Child-Reported Parental Warmth

b) Parent-Reported Parental Warmth

Figure 4. Schematic illustrating the statistically significant relationships between a) child-reported parental warmth, adolescent sleep hygiene and adolescent daytime sleepiness from Wave 1 to Wave 5 and b) parent-reported parental warmth, adolescent sleep hygiene and adolescent daytime sleepiness from Wave 1 to Wave 5. Solid lines = significant paths, dashed lines = non-significant paths. Standardized beta coefficients are presented with standard errors in parentheses.

suggest that child-reported parental warmth may also protect sleep across the course of early- to mid-adolescence, and not only longer-term in early adulthood.

Only five of 31 studies included in the recent meta-analysis used nonadolescent reports of parenting behavior [6], and the predictive ability of child- and parent-reported parental warmth was unknown prior to the current study. There were small, yet inconsistent (e.g. wave 2-4, but not wave 1 or 5, for some but not all variables), cross-sectional associations between parent-reported parental warmth and child-reported morningness/eveningness, school night sleep duration and daytime sleepiness. However, parent-reported parental warmth did not predict changes in child-reported sleep longitudinally. Child- and parent-reported parental warmth were only modestly related (i.e. effect sizes were small), which may partially explain the different pattern of findings in child- versus parent-reported models. Correlations between parent- and child-reported parental warmth were of a similar magnitude to those seen in other studies [i.e. *r* = 0.20–0.40; 36]. Relative to other measures of parenting (e.g. rule setting), measures of parental warmth may be particularly prone to discordance, given the greater focus on emotions (e.g. feeling loved), relative to observable behaviors [36]. Furthermore, discordance between reporters appears to increase from childhood to adolescence [37].

It is likely that adolescents and their parents report quite different perspectives on parental warmth [38]. Child- and parent-reported parental warmth are likely affected by a range of the child and parent's own attitudes, perceptual biases, and reporting styles. Following this latter point, associations between parental warmth and sleep may have been conflated by the single-informant nature of the child-reported models. Extensive evidence points to significant informant disagreement [37] and it is commonplace to show stronger relations between variables when reported by the same informant. On the other hand, parent-reported parental warmth is prone to social desirability bias, which may have masked associations between parental warmth and adolescent sleep, threatening the validity of conclusions drawn from parent-reported models [39]. Indeed, mean parent-reported parental warmth was consistently higher than child-reported parental warmth across all waves, with less variance in responses (i.e. smaller standard deviation).

It has been proposed that children's perceptions of parenting are more important than actual (i.e. objective) or self-reported parenting [36]. The only prior longitudinal study to measure both child- and parent-reported parental warmth created a composite from the two respondents, which obscures reporter differences in the relationships between parental warmth and daytime sleepiness five years later [16]. Furthermore, associations between parent- and child-reported parental warmth were not reported, so it is unclear whether the calculation of a composite score was empirically supported (i.e. whether there was a high enough level of agreement to support this approach) [16]. Though the predictive utility of both parent- and child-reports of parental warmth have never previously been examined in relation to adolescent sleep, there is evidence that only child-reported parental warmth predicts child academic performance, competence and motivation [36]. In addition to concerns regarding socially desirable reporting, it is for this reason that we place greater emphasis on the child-reported models when interpreting the study's findings.

Results from child-reported models support the mediating role of adolescent sleep hygiene behaviors. Namely, sleep hygiene fully mediated the relationship between parental warmth and morningness/eveningness preference, and partially mediated the relationship between parental warmth and both school night sleep duration and daytime sleepiness. As such, this study lends support to Erath and Tu's [21] conceptual model which suggests

that the parent–child relationship indirectly influences child sleep through child self-regulation. Furthermore, even when accounting for the role of sleep hygiene, child-reported parental warmth had a direct effect on sleep duration and daytime sleepiness. Therefore, results from this study support both the direct and indirect pathways between parenting style and child sleep as proposed by Erath and Tu [21]. Partial mediation for sleep duration and daytime sleepiness also suggests that other mechanisms, such as psychological distress, family stress or parental monitoring, may also play a role for these sleep parameters [7, 40, 41].

The current study was the first to test the possibility that the relationship between parental warmth and adolescent sleep is bidirectional. Child-reported models suggest that not only does parental warmth predict adolescent sleep, through sleep hygiene; but adolescent morningness/eveningness and daytime sleepiness predicts parental warmth through sleep hygiene. Further, worse adolescent-reported sleep hygiene predicted reduced parent-reported parental warmth over time. These results support the notion that parenting is a dynamic process, with adolescent characteristics and behaviors also influencing parenting style [21]. These results also converge with those from two recent longitudinal studies using the same sample, which showed i) greater adolescent eveningness and higher daytime sleepiness predicted lower parental control of technology over time [42], and ii) longer adolescent time spent on social media predicted lower parental control of social media over time [43]. While authoritative parenting (characterized by warmth and limit setting) is widely seen as the optimal parenting style for child wellbeing [44], collectively, these studies highlight the impact that child self-control has on the parent–child connection and parent's willingness and/or ability to provide consistent rules (i.e. around sleep, technology and social media use etc.). Despite this bidirectionality, results from this study do suggest that the relationship from parenting to adolescent sleep may be slightly more robust as this association was observed both directly and indirectly, whereas the path from adolescent sleep to parenting occurred only through sleep hygiene; and only for morningness/eveningness and daytime sleepiness (i.e. not sleep duration).

While sleep hygiene was conceptualized as a mechanism linking parental warmth with adolescent sleep, the feedback loop between sleep hygiene practices and adolescent sleep was arguably the most consistent finding from the current study; with longitudinal bidirectional associations between these constructs observed across each of the sleep variables (morning/eveningness, sleep duration, sleepiness) and in both the child- and parent-reported models. Engaging in fewer sleep hygiene practices predicted worsening of sleep and daytime functioning at each timepoint. Further, adolescents at greater risk of inadequate sleep tended to engage in fewer sleep hygiene practices over time. These findings support meta-analytic results, which found sleep hygiene to be an important risk/protective factor across many domains of adolescent sleep (i.e. bedtimes, sleep onset latency, total sleep time) [45]. There is evidence from experimental studies that many components of sleep hygiene (e.g. caffeine and alcohol intake, exercise, stress, noise, sleep regularity, napping) have an influence on sleep [46]. However, results from the current study provide empirical support for the assertion that inadequate sleep may also give rise to poor sleep hygiene practices [46]. In particular, young people may increase unhelpful practices (e.g. reduce daytime activity to conserve energy, use substances to promote sleep and minimize daytime impairment), in an effort to overcome poor sleep, which inadvertently contribute to perpetuation of inadequate sleep.

Clinical implications

First and foremost, results from this study support the inclusion of sleep hygiene content in adolescent sleep interventions. Though the challenge remains that many school-based sleep hygiene interventions increase adolescents' sleep knowledge without changing sleep behaviors; and it is the change in sleep behaviors that seems critical for actual improvement in sleep [47]. Programs that adopt a knowledge-to-action framework are likely to be most successful [48], as are programs that foster adolescent self-efficacy and self-regulation of sleep [49].

Results also support the recommendation of Khor and colleagues [6], that parental warmth is addressed in order to change adolescent sleep. In addition to supporting parents to set clear limits and rules around sleep, parents could be encouraged to i) provide emotional and instrumental social support, ii) communicate encouragement and positive regard, and iii) spend time completing shared activities with their child, all of which may foster a warm relationship [6]. More specifically, results from the current study suggest that parents should approach interactions with their teenager about sleep and sleep-related behaviors in a loving and caring way (i.e. as opposed to in an authoritarian manner). In doing so, parents may better support their teenager to develop the self-regulatory sleep hygiene skills required to promote optimal sleep.

One important point highlighted by the current study, is the impact that adolescent sleep can have upon parental warmth. While it is understandable that having a sleep-deprived adolescent may place strain on the parent–child relationship (e.g. due to increased emotionality and conflict), it should be acknowledged that decreased parental warmth may only serve to further perpetuate poor sleep and other sequalae, creating a vicious cycle. This may be particularly important for clinicians who treat adolescent sleep disorders (e.g. insomnia and Delayed Sleep-Wake Phase Disorder). A previous school-based sleep intervention study has called for the need for more intensive parental involvement (i.e. beyond parent sleep-education alone) [22], and results from the current study suggest that adding therapeutic content to promote parental warmth may be one way to enhance the efficacy of such interventions. Inversely, adolescent sleep hygiene interventions may also directly improve the parent–child relationship.

Limitations and future directions

It is important to consider results and possible implications with the study's limitations in mind. First, all measures included in the study were self-report questionnaires. While this study addresses many of the limitations of prior research (i.e. was longitudinal, multi-informant and measured four sleep-related constructs), the study design would have been strengthened by the inclusion of a sleep diary and an objective measurement of sleep (e.g. actigraphy). The latter is particularly important given discordant findings for subjective and objective sleep duration in previous investigations of the relationship between parental warmth and adolescent sleep [6]. Given sleep duration in the current study was measured using a single item, sleep diary data may provide a more reliable estimate, as well as allowing for other sleep parameters to be calculated and explored. For example, indexes of sleep quality (i.e. sleep onset latency, wake

after sleep onset, sleep efficiency), which are generally more strongly related to psychological functioning. Future studies may also benefit from including parent-reported measure of adolescent sleep, although it should be noted that parent-reports of adolescent sleep are optimistic relative to adolescent self-report and actigraphy (similarly to parent-reported parental warmth) [50]. Further, given parent-and child-reported parental warmth were only modestly related, and parent-report may have been subject to socially desirable reporting, future studies could include a third informant to report on the primary caregiver's parenting style and/or include parent social desirability as a covariate.

While parental warmth appears to encourage adolescents to engage in more positive sleep-related behaviors, it is also possible that emotional warmth from parents promotes better adolescent sleep through fostering feelings of safety and security within the home [45]. Indeed, perceptions of safety, and many other possible mediating mechanisms (e.g., adolescent psychological distress, family stress, parental monitoring) should be investigated in future studies. Finally, other mechanisms that may explain the inverse relationship, from adolescent sleep to parental warmth, should also be examined.

Conclusions

Results from the current study highlight the importance of parenting factors and good sleep hygiene in optimizing adolescent sleep (i.e. in promoting morningness preference, longer sleep duration, less daytime sleepiness). Further, results suggest that adolescent sleep hygiene behaviors are one mechanism that may underpin the association between child-perceived parental warmth and better adolescent sleep. Though adolescent sleep and self-regulatory sleep behaviors also have an effect on the parent-child relationship. Findings support a recent call for parental warmth to be addressed in parent-mediated interventions for adolescent sleep [6]. Yet, this study also highlights the need for clinicians to consider the influence that adolescent sleep may have over parenting style; as decreased parental warmth may act as a barrier to improvement in their teenager's sleep.

Supplementary material

Supplementary material is available at *SLEEP* online.

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Disclosure Statements

Data Availability

Data available on request from the authors.

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