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Le sommeil des enfants: Questions méthodologiques, développementales et familiales

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Le sommeil des enfants: Questions méthodologiques, développementales et familiales

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Résumé

L'objectif général de la thèse était d'accroitre les connaissances empiriques sur le sommeil des enfants mesuré par actigraphie au sein de la population générale.

Le premier article visait à étudier la possibilité d'utiliser dans les études des données d'actigraphie pour lesquelles un agenda de sommeil ne serait pas disponible pour guider la cotation des données. L'échantillon était formé de 60 enfants âgés entre 6 et 10 ans qui ont porté un actigraphe pendant 3 à 7 jours et dont leurs mères ont complété un agenda de sommeil pour la même période. Les données d'actigraphie ont été analysées en utilisant deux conditions de cotation (avec et sans agenda). Les résultats suggèrent que les deux conditions mènent à des résultats similaires, pratiquement identiques au niveau de groupe, quoi que pas interchangeables au niveau intra-individuel. L'article permet de recommander une utilisation parcimonieuse des données d'actigraphie analysées sans agenda de sommeil auprès d'enfants d'âge scolaire.

Le deuxième article avait pour objectif d'étudier les patrons développementaux de sommeil au cours de la période préscolaire. L'échantillon était composé de 128 enfants qui ont porté un actigraphe à 2, 3 et 4 ans et pour qui les courbes de croissance de cinq indices de sommeil ont été modélisées à l'aide d'analyses multi-niveaux. Les résultats ont démontré une diminution linéaire de la durée de sommeil de nuit, de jour et de la durée totale sur 24 heures, ainsi qu'une augmentation linéaire du pourcentage de sommeil ayant lieu durant la nuit et de l'efficacité du sommeil. Cette étude permet de confirmer que des changements développementaux se produisent au niveau de plusieurs indices de sommeil au cours de la période préscolaire et de fournir des repères quantitatifs quant à ce qui est attendu au niveau de ces changements.

Le troisième article visait à étudier la relation père-enfant en tant que potentiel prédicteur des différences interindividuelles dans les courbes de croissance de sommeil au cours de la période préscolaire. Pour 67 enfants, les courbes de croissance de sommeil entre 2 et 4 ans ont été estimées et la qualité des interactions père-enfant ainsi que l'orientation mentale paternelle (tendance du père à commenter les états mentaux présumés de l'enfant) ont été mesurées par observation à 18 mois. Le père a aussi complété un questionnaire évaluant son niveau d'implication auprès de son enfant lorsque celui-ci avait 2 ans. Les résultats n'ont démontré aucune association significative entre les paramètres des courbes de croissance de sommeil et le degré d'implication paternelle ou la qualité des interactions père-enfant. Cependant, les enfants dont le père émettait plus de commentaires appropriés sur leurs états mentaux à 18 mois avaient une plus grande proportion de sommeil durant la nuit ainsi qu'une plus courte durée de sommeil de jour et totale sur 24 heures à 2 ans. Par ailleurs, ces enfants présentaient par la suite des changements moins rapides sur ces variables de sommeil entre 2 et 4 ans. Ainsi, l'article 3 permet de conclure que les enfants exposés à un plus haut niveau d'orientation mentale paternelle semblent atteindre des patrons de sommeil plus matures plus tôt dans leur développement.

Mots-clés: Sommeil de l'enfant; Actigraphie; Agendas de sommeil; Développement; Longitudinal; Période préscolaire; Relation père-enfant; Orientation mentale

Abstract

The overall objective of this thesis was to contribute new empirical knowledge on children's sleep assessed using actigraphy among typically-developing children.

The first article aimed to investigate the possibility for studies to use actigraphic data for which a sleep diary would not be available to guide the scoring of the data. The sample was composed of 60 children aged 6 to 10 years who wore an actigraph for 3 to 7 days and whose mothers completed a sleep diary for the same period. Actigraphic data were analyzed using two scoring conditions (with and without diary). The results suggest that the two conditions lead to similar results, virtually identical at the group level, but not interchangeable at the intra-individual level. This paper leads to the recommendation of parsimonious use of actigraphic data analyzed without a sleep diary.

The second article aimed to study the developmental patterns of sleep in the preschool period. The sample included 128 children who wore an actigraph at 2, 3, and 4 years of age and for which the growth curves of five sleep indices were modeled using multi-level analyses. The results demonstrated a linear decrease in nighttime, daytime and 24-hour total sleep duration as well as a linear increase in the proportion of sleep taking place during the night and in sleep efficiency. This study confirms that developmental changes occur in several sleep variables during the preschool period and helps to provide quantitative points of reference regarding these changes.

The third article aimed to examine different aspects of the father-child relationship as potential predictors of inter-individual differences in sleep growth curves during the preschool period. For 67 children, sleep growth curves between 2 and 4 years were estimated and the quality of father-child interactions as well as paternal mind-mindedness (fathers' tendency to comment on child's presumed mental states) were assessed by observation at 18 months. Fathers also completed a questionnaire assessing their involvement with their child at the age of 2 years. The results showed no significant association between sleep growth curves parameters and the degree of father involvement or the quality of father-child interactions. However, children whose fathers made more appropriate comments about their mental states at 18 months had a higher proportion of nighttime sleep as well as shorter daytime sleep duration and shorter 24-hour total duration at 2 years. In addition, these children subsequently exhibited less rapid changes in these sleep variables between 2 and 4 years. This paper suggests that children exposed to higher levels of paternal mind-mindedness appear to achieve more mature sleep patterns earlier in their development.

Keywords : Child sleep; Actigraphy; Sleep diary; Development; Longitudinal, Preschool; Father-child relationship; Mind-mindedness

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Liste des abréviations

CDN	Canadian
FIML	Full Information Maximum Likelihood
HLM	Hierarchical Linear Modeling
HRV	Heart Rate Variability
ICC	Intraclass Correlation
LL	Log Likelihood
MFIQ	Montreal Father's Involvement Questionnaire
MLM	Multilevel Modeling
MRO	Mutually Responsive Orientation scale
PIM	Proportional Integration Mode
PNS	Parasympathetic Nervous System
PSG	Polysomnography

À ma famille.

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Introduction

Durant l'enfance, un développement sain nécessite une quantité et une qualité de sommeil suffisantes (El-Sheikh & Sadeh, 2015). Les problèmes de sommeil (ex., sommeil de courte durée ou de faible qualité, horaires de sommeil irréguliers, somnolence diurne) sont fréquents chez les enfants (Mindell & Owens, 2015) et peuvent avoir des conséquences négatives sur de multiples domaines de leur développement, dont le fonctionnement cérébral (Dutil et al., 2018), le développement cognitif (Smithson et al., 2018), l'ajustement à l'école (Williams et al., 2016), la réussite scolaire (Gruber et al., 2014), ainsi que la capacité chez l'enfant à réguler ses émotions (Miller et al., 2015) et ses comportements (Bélanger, Bernier, Simard, Desrosiers et al., 2015). De plus, les problèmes de sommeil chez les jeunes enfants vont souvent persister tout au long de l'enfance (Mindell & Owens, 2015) et ouvrir la porte à des difficultés émotionnelles et d'apprentissage à l'adolescence (Silva et al., 2011). Considérant le rôle qu'il joue dans le développement, il semble important d'étudier soigneusement le sommeil des enfants et de cerner les facteurs pouvant l'influencer, notamment pour identifier assez tôt les enfants présentant des difficultés de sommeil afin d'intervenir pour contrer ces difficultés. Pour ce faire, les connaissances à propos des méthodes permettant de mesurer le sommeil auprès des enfants ainsi qu'au sujet du développement normatif du sommeil au cours de l'enfance sont essentielles.

Un enjeu majeur dans l'étude du sommeil auprès des enfants est d'utiliser des instruments de mesure adéquats, qui permettent de mesurer le sommeil de façon valide tout en minimisant l'interférence avec l'environnement et les habitudes de vie de l'enfant et de sa famille. Dans ce contexte, l'actigraphie, un petit moniteur informatisé qui se porte comme une montre et qui permet d'enregistrer le niveau d'activité, a souvent été reconnue comme un moyen valide et peu intrusif qui permet de mesurer adéquatement le sommeil chez les enfants dès les premiers jours de vie (Meltzer et al., 2012; Meltzer & Westin, 2011; Sadeh, 1995; 2015). Il est pratique courante d'utiliser l'actigraphie conjointement avec un agenda ou journal du sommeil rempli par le parent, qui permet de corroborer les données d'actigraphie. Cette pratique peut par ailleurs entrainer une perte de données, sachant que les données d'un participant pour qui les données d'actigraphie sont disponibles, mais pas l'agenda de sommeil, seront exclues (Meltzer & Westin, 2011). Le premier objectif de cette thèse est donc de comparer les données d'actigraphie d'enfants d'âge scolaire (6-10 ans) analysées avec et sans agenda parental de sommeil afin de déterminer s'il serait possible, dans les études futures, d'utiliser une portion de données d'actigraphie pour lesquelles les données d'agenda ne seraient pas disponibles.

Dans un autre ordre d'idées, les connaissances au sujet du sommeil normatif chez les enfants sont essentielles afin de déterminer quels enfants présentent des patrons de sommeil attendus pour leur âge et lesquels semblent présenter des difficultés de sommeil ou un sommeil qui s'éloigne de la normalité et pourraient ainsi nécessiter une attention clinique. En plus de pouvoir juger si un enfant atteint les niveaux attendus à un âge précis, il importe d'avoir des normes quant aux *développements* attendus dans le sommeil entre certains âges afin de juger si les changements observés dans le sommeil d'un enfant correspondent à un développement normatif ou atypique, voir pathologique. Ceci est particulièrement important pour les périodes de l'enfance où le sommeil est marqué par des développements importants, comme à l'âge préscolaire, où les parents et les cliniciens peuvent se questionner quant au caractère souhaitable et attendu des changements qu'ils observent dans le sommeil des enfants. Le deuxième objectif de la thèse est donc de fournir des points de repères quantitatifs quant aux développements de différents indices de sommeil (ex., durée, qualité, distribution) à travers la période préscolaire et d'étudier les différences interindividuelles dans ces développements.

Finalement, il est généralement bien reconnu que les relations parent-enfant et les comportements parentaux jouent un rôle important dans plusieurs sphères développementales chez les enfants, notamment le sommeil. Ce lien a été démontré dans plusieurs études, mais la plupart portaient sur la relation mère-enfant. De plus, très peu d'études ont examiné le lien entre la relation parent-enfant et le développement du sommeil à travers différents âges. Le troisième objectif de la thèse est donc de déterminer si la relation père-enfant constitue un prédicteur des différences interindividuelles dans les développements qui ont lieu au niveau du sommeil à l'âge préscolaire.

Dans cette introduction, nous aborderons dans un premier temps l'actigraphie en tant que mesure de sommeil chez les enfants. Nous nous intéresserons par la suite au sommeil normatif ainsi qu'aux développements attendus dans le sommeil durant l'enfance et plus particulièrement au cours de la période préscolaire. Les différents facteurs biopsychosociaux pouvant influencer le sommeil de l'enfant seront discutés. L'association entre les relations parent-enfant et le sommeil sera ensuite approfondie, puis la pertinence de se pencher sur les associations entre la relation père-enfant et le sommeil de l'enfant sera exposée. Enfin, les objectifs et les hypothèses de la thèse seront présentés.

L'actigraphie comme mesure de sommeil chez les enfants

Il existe plusieurs méthodes permettant de mesurer le sommeil chez les enfants, les plus communes étant la polysomnographie, la vidéosomnographie, l'actigraphie, les observations directes, les agendas de sommeil et les questionnaires. Chaque méthode présente des avantages ainsi que des inconvénients et permet d'étudier des aspects distincts du sommeil (voir Sadeh, 2015, pour une description exhaustive et une comparaison des avantages et inconvénients des différentes méthodes). Parmi les différents instruments, l'actigraphie constitue une méthode objective relativement peu coûteuse et peu invasive. Un actigraphe est un petit moniteur informatisé en forme de montre que l'enfant porte à la cheville ou au poignet et qui enregistre en continu les mouvements à l'aide d'un accéléromètre. L'activité motrice (nombre de mouvements) est ainsi enregistrée par périodes de temps (généralement 30 secondes ou une minute) et cette activité sert ensuite à inférer les moments d'éveil et de sommeil à l'aide d'algorithmes validés empiriquement. L'actigraphie permet d'obtenir des mesures de différents aspects du sommeil tels que la durée (la durée de sommeil de jour et de nuit ainsi que la durée totale sur 24 heures), la latence (le nombre de minutes entre le coucher et l'endormissement), la qualité (le nombre et la durée des éveils nocturnes, le pourcentage d'efficacité du sommeil) et la distribution (les heures de coucher et de lever, le pourcentage de sommeil ayant lieu durant la nuit). Toutefois, comme elle est basée sur le niveau d'activité motrice, elle ne permet pas de mesurer l'architecture du sommeil (ex., les stades de sommeil ou la proportion de temps en sommeil paradoxal) ou l'activité du cerveau pendant le sommeil, contrairement à la polysomnographie, qui est reconnue comme étant la méthode par excellence pour mesurer le sommeil (Sadeh, 2015). L'actigraphie possède cependant une meilleure validité écologique, permet de mesurer le niveau d'activité en continu 24 heures sur 24 et nécessite moins de ressources, notamment parce qu'elle peut être utilisée dans l'environnement naturel, qu'elle ne nécessite aucune installation et que l'analyse des données est relativement simple. Lors de l'analyse, il est toutefois important de s'assurer d'éliminer les artéfacts potentiels qui peuvent altérer la validité des données. Ces artéfacts peuvent être introduits entre autres par l'enregistrement de mouvements induits par un objet extérieur (ex., si l'enfant dort dans une poussette ou une voiture), du retrait de l'actigraphe, ou de moments d'éveils où l'enfant est immobile (ex., regarde la télévision sans bouger). Pour s'assurer de détecter la présence de tels artéfacts dans les données, les chercheurs qui utilisent l'actigraphie auprès des enfants demandent habituellement aux parents de compléter un agenda ou journal de sommeil qu'ils utilisent ensuite pour identifier les artéfacts et exclure les données concernées. Cette méthode permet de maximiser la validité des données d'actigraphie, mais mène aussi à l'exclusion de données potentiellement valides lorsque l'agenda de sommeil n'est pas disponible – la pratique courante étant alors d'exclure les données d'actigraphie correspondantes. Cette exclusion peut entrainer différents biais, par exemple en réduisant la puissance statistique, alors que la taille de l'échantillon est souvent déjà modeste dans les études utilisant l'actigraphie auprès des enfants. Jusqu'à présent, très peu d'études ont testé empiriquement s'il pouvait être possible, sans altérer la validité des données, d'utiliser une portion de données d'actigraphie pour lesquelles il n'y aurait pas de donnée d'agenda disponible. Le premier article de la thèse aborde cette question et a pour objectif d'évaluer l'impact que peut avoir le fait d'effectuer la cotation des données d'actigraphie sans utiliser d'agenda complété par le parent lors de l'étude du sommeil des enfants.

Le sommeil normatif et les développements dans le sommeil à l'âge préscolaire

Il est généralement admis que la période préscolaire est caractérisée par des développements importants dans le sommeil, principalement une consolidation des cycles éveil-sommeil, une concentration croissante du sommeil durant la nuit, ainsi qu'une diminution de la durée de sommeil totale et particulièrement de sommeil de jour (Acebo et al., 2005; Iglowstein et al., 2003). Toutefois, ces connaissances sont presque exclusivement issues d'études ayant employé une méthodologie qui ne permet pas d'étudier de véritables patrons de changement dans le sommeil.

Pour commencer, la plupart de ces études sont transversales et documentent le sommeil d'enfants différents répartis dans des groupes d'âge distincts, et non pas des études longitudinales qui suivent les mêmes enfants alors qu'ils grandissent. Ces études ne permettent donc pas d'étudier le *développement* du sommeil, car les enfants sont différents d'un groupe d'âge à l'autre (ex., Acebo et al., 2005; Crosby et al., 2005; Ward et al., 2008). Ainsi les changements intra-individuels d'un âge à l'autre sont confondus avec les différences interindividuelles entre enfants qui diffèrent en âge mais possiblement sur plusieurs autres facteurs également.

Certaines études ont, quant à elles, utilisé un devis longitudinal et ont donc mesuré à plusieurs reprises le sommeil auprès des mêmes enfants (Anders et al., 2011; Scher et al., 2004; Staples et al., 2015). Bien que ces études soient utiles afin de déterminer le niveau de stabilité relative (à quel point les enfants maintiennent leur rang au sein du groupe à travers le temps sur un indice de sommeil), les analyses statistiques utilisées ne permettent pas de quantifier le changement intra- et interindividuel à travers le temps, et donc de tirer de conclusion sur les trajectoires de développement suivies par chaque enfant à travers le temps (différences intra-individuelles; Bornstein et al., 2017). Il n'est donc pas possible, à partir de ces études, de se positionner sur le patron de changement que suit le sommeil et de voir par exemple si le changement est linéaire, s'il augmente pour ensuite se stabiliser ou diminuer, ou encore s'il est constant ou fluctue dans le temps. Ces études ne permettent pas non plus de comparer les enfants au niveau de ces patrons de développement (différences interindividuelles) et de déterminer, par exemple, quels enfants atteignent plus rapidement la maturité au niveau de leur sommeil et à quels potentiels prédicteurs ces différences pourraient être attribuables. Pour ce faire, des études longitudinales utilisant des analyses statistiques avancées telles que des analyses multiniveaux sont nécessaires afin d'examiner les développements que suivent différents indices de sommeil au cours de la période préscolaire, puis d'étudier la contribution potentielle de certains prédicteurs aux différences interindividuelles dans ces développements par exemple des évolutions plus rapides ou plus lentes chez certains enfants (Bornstein et al., 2017).

Au cours des dernières décennies, un petit nombre d'études se sont intéressées à de telles trajectoires développementales de sommeil à l'âge préscolaire, mais les conclusions issues de ces études sont limitées par différents facteurs méthodologiques. Pour commencer, ces études ont chacune porté sur une seule variable de sommeil, soit la durée de sommeil de nuit (Plancoulaine et al., 2018; Touchette et al., 2008; 2009), la durée de sommeil totale (Magee et al., 2014), les problèmes de sommeil (Kocevska et al., 2017; Williamson et al., 2019) ou la fréquence des éveils nocturnes (Weinraub et al., 2012). Ainsi, il n'y a actuellement pas d'information disponible, à notre connaissance, sur d'autres variables de sommeil, notamment l'efficacité de sommeil, le pourcentage de sommeil ayant lieu durant la nuit, ou même la durée de sommeil de jour, qui représente pourtant l'une des variables sur laquelle des changements majeurs sont attendus. De plus, chaque variable de sommeil étant étudiée auprès d'un échantillon différent, on ne peut établir de liens entre les différents développements, par exemple que le sommeil total diminue *parce que* le sommeil diurne diminue, ou bien que l'efficacité du sommeil doit d'abord augmenter pour que sa durée puisse ensuite décliner. Par ailleurs, toutes ces études ont utilisé des rapports parentaux afin de mesurer le sommeil des enfants, ce qui peut mener à différents biais relatifs au parent, au niveau d'adhérence et au fardeau que remplir le questionnaire ou l'agenda de sommeil peut représenter (Sadeh, 2015). Il est d'ailleurs bien établi que les rapports parentaux présentent une faible validité lorsqu'on cherche à mesurer des indices de qualité de sommeil, par exemple les éveils nocturnes (ex., Bélanger et al., 2014; Mazza et al., 2020).

Ainsi, il y a toujours peu de consensus en ce qui concerne les changements développementaux normatifs dans le sommeil à l'âge préscolaire. Pourtant, de telles normes sont importantes pour aider les parents et les professionnels à distinguer les enfants dont le sommeil change de manière normative de ceux qui manifestent un sommeil en détérioration ou encore un sommeil qui ne démontre pas les améliorations développementales attendues. De plus, puisque le sommeil est un processus dynamique qui connait des changements marqués durant l'enfance, comprendre comment le sommeil change à travers le temps est une étape importante pour être en mesure d'étudier les relations entre le sommeil de l'enfant et les variables qui y sont associées (Bub et al., 2011). Il apparait ainsi essentiel d'étudier les patrons de développement de différents indices de sommeil à l'âge préscolaire à l'aide de devis longitudinaux, de techniques statistiques permettant de modéliser de véritables patrons de changement et de mesures de sommeil objectives qui permettent de contourner les biais inhérents aux rapports parentaux. À l'aide d'une telle méthodologie, le deuxième article de la thèse étudie les patrons de développement de différents indices de la durée, la distribution sur un cycle de 24 heures et l'efficacité du sommeil au cours de la période préscolaire.

Le rôle de facteurs biologiques et sociaux dans le sommeil de l'enfant

Il est généralement admis que le sommeil de l'enfant peut être influencé par de multiple facteurs biologiques, sociaux et culturels (El-Sheikh & Kelly, 2017; Sadeh & Anders, 1993). Par exemple, le développement des patrons de sommeil-éveil est en partie entraîné par la maturation et l'interaction de deux processus biologiques intrinsèques : les processus homéostatique et circadien. Le processus homéostatique fait en sorte que le besoin de sommeil s'accumule pendant l'éveil et se dissipe pendant le sommeil alors que le processus circadien fournit de façon cyclique des signaux encourageant à certains moments la vigilance et à d'autres moments le sommeil, indépendamment du temps d'éveil et de sommeil précédent (Jenni & Carskadon, 2007; Jenni & LeBourgeois, 2006). Une importante tâche développementale pour les jeunes enfants serait de parvenir à aligner ces deux processus, menant ainsi à la consolidation du sommeil – ou, en cas d'échec, à une grande latence de sommeil, des éveils nocturnes fréquents et prolongés et de la fatigue diurne. Les expériences sociales et culturelles, notamment les relations parent-enfant et les pratiques parentales face au sommeil de l'enfant, le fonctionnement des siestes à la garderie ainsi que les valeurs et attentes culturelles, contribueraient à aligner ces processus et influenceraient ainsi la régulation du rythme circadien (Dearing et al., 2001; Jenni & Carskadon, 2007).

Ainsi, au cours de l'enfance, le sommeil serait influencé par de multiples facteurs biologiques et environnementaux (El-Sheikh & Sadeh, 2015). En fait, il est parfois proposé que les facteurs biologiques expliqueraient une grande partie des différences individuelles dans le sommeil des nourrissons, alors que les facteurs environnementaux pourraient jouer un rôle croissant lorsque les enfants vieillissent (Dearing et al., 2001). Il a notamment été proposé que l'influence des relations parent-enfant sur l'autorégulation (et donc possiblement la régulation du sommeil) serait plus saillante à partir de 12 mois environ, en lien avec la maturation dans le cerveau du système limbique, qui serait particulièrement sensible aux fluctuations dans la relation parent-enfant (Schore, 1996). À l'âge préscolaire, les influences environnementales pourraient donc être saillantes et, parmi celles-ci, il a fréquemment été suggéré que les relations parent-enfant auraient un rôle considérable à jouer dans la régulation du sommeil de l'enfant.

Les relations parent-enfant

Chez les enfants, le développement de la régulation du sommeil est influencé par l'environnement physique et psychosocial (Sadeh & Anders, 1993; Sadeh et al., 2010), notamment le contexte familial (Dahl & El-Sheikh, 2007; El-Sheikh & Kelly, 2017), l'ajustement personnel et conjugal chez les parents (El-Sheikh et al., 2012; El-Sheikh et al., 2015) et les relations parent-enfant (Bernier et al., 2019; El-Sheikh & Kelly, 2017).

Il a été proposé qu'un sentiment de sécurité physique et émotionnelle est essentiel pour s'endormir et pour rester endormi, sachant que le sommeil implique une diminution dramatique de la vigilance (Dahl & El-Sheikh, 2007). Toutefois, le moment du coucher représenterait un moment anxiogène pour les jeunes enfants, notamment en raison de la noirceur et de la séparation prolongée d'avec les parents qui y sont généralement associées dans les sociétés occidentales (Keller, 2011). Dès la petite enfance, les comportements parentaux et plus globalement les relations parent-enfant vont permettre à l'enfant de développer un sentiment de sécurité (Ainsworth et al., 1978). Face à l'anxiété associée au moment du coucher et des éveils nocturnes, les parents agiraient comme régulateurs externes des affects de l'enfant, lui fourniraient un sentiment de sécurité et soutiendraient ainsi le développement de sa capacité d'autorégulation (Calkins & Hill, 2007) qui est requise pour diminuer la vigilance et donc pour s'endormir ou se rendormir après un éveil.

Durant l'enfance, les parents et les enfants établissent ensemble des patrons de comportements quant à l'endormissement (ex., s'endormir côte à côte ou pas, établir ou pas des routines de soirée) et aux éveils nocturnes (ex., venir ou pas prendre l'enfant dans ses bras lorsque celui-ci se réveille, appeler ou pas ses parents lors d'un éveil). La relation entre les comportements parentaux au coucher et durant la nuit et le sommeil de l'enfant a fait l'objet de plusieurs études (ex., Mindell et al., 2010; Philbrook & Teti, 2016; Simard et al., 2011; Touchette et al., 2005; voir Bernier et al., 2019 pour une recension). En général, ces études ont montré que les pratiques parentales encourageant l'autonomie et l'autorégulation de l'enfant durant la nuit plutôt que la dépendance envers la présence des parents étaient associées à un sommeil optimal chez l'enfant.

Toutefois, il importe de préciser que ce ne sont pas uniquement les comportements parentaux directement liés au sommeil qui pourraient avoir un impact sur le sommeil de l'enfant. Toutes les interactions parent-enfant, incluant celles qui ont lieu le jour, contribueraient au contexte émotionnel général de la relation parent-enfant et en retour, à la sécurité affective et au sommeil de l'enfant. À ce sujet, le sentiment de sécurité de l'enfant au sein de sa relation avec son parent serait expliqué en grande partie par l'historique des interactions parent-enfant ayant lieu durant la journée (De Wolff & Van IJzendoorn, 1997). Plusieurs études empiriques ont démontré des liens entre le sommeil des enfants et différents aspects de la relation parent-enfant tels que la sensibilité parentale (Bell & Belsky, 2008; Tétreault et al., 2016), la sécurité d'attachement (Bélanger, Bernier, Simard, Bordeleau et al., 2015; Simard et al., 2017; Vaughn et al., 2011) et la qualité des interactions parent-enfant (Bordeleau et al., 2012; Dubois-Comtois et al., 2019). Cependant, la majorité de ces études se sont concentrées sur les comportements maternels et sur la relation mère-enfant.

La relation père-enfant. En comparaison avec la relation mère-enfant, la relation père-enfant a été peu étudiée en lien avec le sommeil de l'enfant. Pourtant, depuis quelques décennies, les pères sont de plus en plus impliqués dans les soins aux enfants (Schoppe-Sullivan & Fagan, 2020), notamment au moment du coucher et durant la nuit (ex., Goodlin-Jones et al., 2001; Tikotzky et al., 2011).

Dans la dernière décennie, des études empiriques ont commencé à documenter le lien entre le sommeil de l'enfant et différents aspects de la relation père-enfant, notamment le niveau d'implication du père dans les soins et l'éducation du nourrisson (Tikotzky et al., 2011; Tikotzky et al., 2015) et de l'enfant d'âge préscolaire (Bernier et al., 2017; Millikovsky-Ayalon et al., 2015), la qualité des interactions père-enfant (Bordeleau et al., 2012; Dubois-Comtois et al., 2019) et les comportements paternels hostiles (Rhoades et al., 2012) au préscolaire, ainsi que l'attachement père-enfant (Keller & El-Sheikh, 2011) et la présence du père dans le milieu familial (Bell & Belsky, 2008) à l'âge scolaire.

Dans l'ensemble, ces études suggèrent que la relation père-enfant pourrait influencer le sommeil de l'enfant à différentes périodes de l'enfance. Toutefois, les études documentant ces associations demeurent peu nombreuses, et aucune n'a étudié, à notre connaissance, les associations entre la relation père-enfant et le *développement* du sommeil de l'enfant au cours d'une période développementale. Les pères tendent à s'impliquer davantage dans la vie de leur enfant à partir de la fin de la première année de vie (vers 12-18 mois; NICHD Early Child Care Network, 2000).Ainsi, l'augmentation du niveau d'implication du père surviendrait juste avant la période préscolaire, où il se produit des développements importants dans le sommeil (Acebo et al., 2005; National Sleep Foundation, 2004). Il apparait donc prometteur d'investiguer si la relation père-enfant pourrait contribuer à la variation interindividuelle dans ces développements, et donc si une relation père-enfant de meilleure qualité pourrait être associée à une maturation plus rapide des patrons de sommeil chez l'enfant. De plus, les études réalisées jusqu'à présent se sont concentrées sur un seul aspect de la relation père-enfant, alors que différentes dimensions de cette relation (ex., degré d'implication paternelle, comportements paternels spécifiques, attachement père-enfant, qualité générale de la relation et autres) pourraient être associées avec le sommeil de l'enfant, tel que les études présentées ci-haut semblent le suggérer. Le troisième article de la thèse a ainsi pour but d'étudier les associations entre différents aspects de la relation père-enfant et les patrons développementaux de changements de différents indices de sommeil au cours de la période préscolaire.

Objectifs de la thèse et hypothèses

L'objectif général de la thèse est d'accroitre les connaissances scientifiques sur le sommeil des enfants mesuré par actigraphie en examinant la méthode de cotation des données à l'âge scolaire et en se penchant sur des questions développementales et familiales, soit le développement du sommeil à travers l'âge préscolaire et le potentiel rôle prédicteur de la relation père-enfant dans ce développement. La thèse se compose des trois articles empiriques suivants, visant chacun à approfondir une facette de la recherche en sommeil auprès des enfants d'âge préscolaire et scolaire.

L'article 1 vise à étudier la possibilité d'utiliser des données d'actigraphie en l'absence d'agenda parental (habituellement utilisé pour guider la cotation des données d'actigraphie). Deux conditions de cotation des données d'actigraphie sont employées (une condition dans laquelle la cotation est guidée par un agenda de sommeil et une seconde condition dans laquelle la cotation se fait sans utiliser d'agenda), puis le degré de concordance entre les deux conditions est examiné. Au vu du manque de littérature préalable, aucune hypothèse n'est formulée concernant le degré de concordance entre les deux méthodes de cotation. Cet article a été publié dans la revue *Sleep Medicine* en 2018. Cette étude est menée auprès d'enfants d'âge scolaire, alors que les deux autres études (articles 2 et 3) se concentrent plutôt sur la période préscolaire, vu la pertinence développementale de cette période pour les questions abordées.

L'article 2 utilise un devis longitudinal en trois temps (2, 3 et 4 ans) et des analyses multiniveaux afin d'étudier les patrons développementaux de changements de cinq indices de sommeil mesurés par actigraphie au cours de la période préscolaire. Des indicateurs de la durée, de la qualité et de la distribution du sommeil sur un cycle de 24 heures sont inclus, permettant ainsi d'avoir un portrait du développement de différents aspects du sommeil durant l'âge préscolaire (différences intra-individuelles d'un âge à l'autre), ainsi que des variations entre les enfants au niveau de ces développements (différences interindividuelles). Il est attendu qu'entre 2 et 4 ans les données montrent une stabilité dans la durée de sommeil de nuit, une diminution linéaire de la durée de sommeil de jour et durée totale sur 24 heures, ainsi qu'une augmentation linéaire du pourcentage de sommeil ayant lieu durant la nuit et de l'efficacité de sommeil. Cet article a été publié dans la revue *Developmental Psychobiology* en 2019.

L'article 3 vise à déterminer si trois différents aspects de la relation père-enfant (orientation mentale paternelle, qualité des interactions père-enfant et niveau d'implication paternelle) prédisent les différences inter-individuelles dans les patrons développementaux de changements de cinq variables de sommeil mesurées par actigraphie au cours de la période préscolaire (les variables pour lesquelles les courbes de croissance ont été modélisées dans l'article 2). L'orientation mentale fait référence à la tendance du père à commenter de façon appropriée les états mentaux présumés de l'enfant (Meins et al., 2001), la qualité des interactions père-enfant représente le degré auquel les interactions sont caractérisées par une communication harmonieuse, une coopération mutuelle et une atmosphère émotionnelle positive (Aksan et al., 2006) et l'implication paternelle fait référence à la mesure dans laquelle les pères sont impliqués auprès de leur enfant, notamment dans les soins, les jeux ou activités, l'éducation, le soutien émotionnel et la discipline (Cabrera et al., 2000). En se basant sur le fait que ces trois aspects de la relation père-enfant pourraient théoriquement encourager le développement de la capacité d'auto-régulation chez les enfants, il est possible de s'attendre à ce que de plus hauts scores sur ces prédicteurs soient associés à une régulation optimale des cycles éveil-sommeil à travers la période préscolaire. Cependant, considérant l'absence d'étude antérieure sur le sujet, aucune hypothèse précise n'a été formulée quant à la valeur prédictive relative de ces aspects de la relation père-enfant en lien avec les indicateurs de développement du sommeil à l'âge préscolaire. Cet article a été publié dans la revue *Developmental Psychobiology* en 2021.

Article 1

Actigraphy data in pediatric research: The role of sleep diaries

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Actigraphy data in pediatric research: The role of sleep diaries

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Abstract

Background: When assessing children's sleep using actigraphy, researchers usually rely on a sleep diary completed by a parent as an aid in scoring actigraphic data. However, parental non-adherence in completing the sleep diary may significantly reduce the amount of available data. The current study examined the agreement between actigraphic data scored with and without a sleep diary in order to evaluate the impact of not using a sleep diary when studying children's sleep with actigraphy.

Methods: Sixty children (6-10 years; 36 girls) wore an actigraph for three to seven consecutive nights, and mothers were asked to complete a diary of their child's sleep during the same period. Actigraphic data were scored using two conditions (with and without diary) rated independently for each child by two different research assistants, who each scored 50% of the files in each condition.

Results: Group-level analyses and intraclass correlations revealed very strong convergence between the two scoring conditions: on all sleep variables (sleep duration, wake duration, and sleep efficiency), average mean differences were very small and intraclass correlations very high. Bland and Altman's (1999) approach allowed for a child-by-child examination of agreement between the two conditions and revealed that, although they cannot be considered interchangeable, the two conditions produce quite minimal differences in the estimation of sleep variables.

Conclusions: The findings suggest that it is possible to use some actigraphy data for which no corresponding diary data are available, although this approach should be used sparingly.

Keywords: Sleep, Actigraphy, Children, Sleep diary, Scoring

Actigraphy data in pediatric research: The role of sleep diaries.

1. Introduction

Children's sleep problems are common (Mindell & Owens, 2010) and usually persist throughout childhood (Lavigne et al., 1999). It has been observed that sleep difficulties tend to become chronic around 3 years of age, such that two thirds of children who had sleep problems before this age still suffered from such problems five years later (Thome & Skuladottir, 2005). Furthermore, sleep is linked to multiple areas of child development, such as cognitive (Bernier, Beauchamp, Bouvette-Turcot, Carlson, & Carrier, 2013), emotional (Gregory et al., 2005), behavioral (Bélanger, Bernier, Simard, Desrosiers, & Carrier, 2016) and physiological (e.g., later risk of obesity; Reilly et al., 2005) adjustment, suggesting that sleep disturbances can have a negative impact on several spheres of child functioning. Thus, accurate assessment of the duration and quality of children's sleep is important for pediatric research and practice.

Different methods are used to evaluate sleep in childhood; some are subjective (child or parent interviews, parental retrospective questionnaires, prospective sleep diaries), whereas others are objective. Among the latter, actigraphy, based on the use of a small watch-like computerized monitor, allows for non-intrusive assessment of sleep/wake patterns in infants', children's, and adolescents' natural environment (Sadeh, Lavie, Scher, Tirosh, & Epstein, 1991). The monitor can be worn at the wrist, the ankle or the waist. The number of movements per epochs (e.g., 30 sec) is recorded continually with a movement accelerometer. Scoring algorithms are then used to identify sleep and wake states from activity counts and to determine sleep variables such as sleep onset latency (number of minutes elapsed from bedtime to sleep onset), sleep duration (number of minutes scored as sleep between sleep onset and offset), frequency of awakenings (number of times that a predetermined number of minutes of wake occurs, e.g., 5 minutes), wake duration (number of minutes scored as wake between sleep onset and offset), and sleep efficiency (ratio of sleep duration to total time in bed *100). There are different brands of actigraphs and different scoring programs (e.g., Meltzer, Walsh, et al., 2012).

Studies suggest that some sleep variables are challenging to assess with actigraphy, as indicated by their poor convergence with corresponding polysomnographic (PSG) estimates (e.g., number of awakenings, sleep fragmentation or efficiency; Bélanger, Bernier, Paquet, Simard, & Carrier, 2013; Meltzer, Walsh, et al., 2012; Spruyt, Gozal, Dayyat, Roman, & Molfese, 2011). Overall, though, actigraphy is recognized as a valid and reliable method to assess sleep objectively (Berger et al., 2008; Meltzer, Montgomery-Downs, et al., 2012; Sadeh, 2011), as indicated notably by its convergence with PSG estimates on several sleep variables (e.g., sleep latency, sleep duration; Bélanger et al., 2013; Meltzer, Walsh, et al., 2012; Spruyt et al., 2011). Consequently, it has become frequent practice to use activity monitoring to assess children's sleep. Used jointly with validated algorithms, actigraphy constitutes a useful, valid, and relatively inexpensive way to collect naturalistic sleep data over multiple days.

There are, however, important challenges associated with actigraphic analyses, notably the detection of spurious motor activity counts associated with external motion (when a child sleeps in a vibrating vehicle like a car or a stroller) and the failure to detect motion due to removal of the actigraph. Furthermore, actigraphic algorithms cannot discriminate between motionless wakefulness (e.g., when the child is watching television in bed) and sleep (Sadeh, 2015). To improve detection of these situations, pediatric actigraphic studies usually rely on sleep diaries completed by a parent (often the mother). There are different types of sleep diaries, which vary in terms of the exact information asked from the parent. However, all sleep diaries can aid in scoring actigraphy data by helping to identify artifacts in actigraphy data, and also provide relevant information such as the approximate time when the child went to sleep and woke up the next morning, which helps determine sleep onset and offset times from the actogram (graphical representation of activity level provided by the actigraphy software). Diaries are also useful in identifying particular events that may have caused an atypical night for the child (e.g., illness or visitors at home). Researchers can then use this information in analyzing the data or to decide which data should be excluded (e.g., periods where the data are likely biased by artifacts). An important challenge, however, is that diary data are often not available. Although some do not provide the exact proportions, several papers using actigraphy mention that participants or specific nights were discarded given the parent's failure to fill out the sleep diary (e.g., Bélanger, Bernier, Simard, Bordeleau, & Carrier, 2015; Sitnick, Goodlin-Jones, Anders, 2008; Werner et al., 2008). In fact, a study by Acebo and colleagues (1999) found that when recording nights for a week with children and adolescents, a loss of up to 28% of data can be expected, for reasons including illness and technical problems, but also failure to complete the diary. This is not unexpected, as participants' perfect compliance with any research procedure can never be taken for granted. In the case of children's sleep diaries, the parent may fail to complete the sleep diary, on one or multiple days, and it is not developmentally realistic to expect children, especially young children, to assume responsibility for completing a sleep diary. While understandable, such non-compliance is of concern because even in cases where the diary was partially completed (e.g., on 3 or 4 nights out of 7), a participant's data could have to be deleted altogether, as Acebo et al. (1999) recommended that at least five nights of actigraphy recordings were necessary to assess sleep reliably. Thus, not only can parental (or child) non-adherence in completing the sleep diary reduce the number of scorable nights, it can also reduce the number of participants, due to the need to exclude participants who have fewer than a pre-specified number of scorable nights. Thus, non-adherence in completing the sleep diary constitutes a great challenge, as it may significantly reduce the number of nights and participants in a given study, potentially resulting in dramatic loss of statistical power. This is a salient issue for pediatric sleep studies, given that small samples are the norm rather than the exception in such studies. Furthermore, using only participants or nights for which sleep data are available on both measures (diary and actigraphy) could lead not only to reduced statistical power, but also to a non-random bias inherent to certain participants' or nights' characteristics, leading to less representative results.

One important yet under-studied question, then, is whether it might be possible to use some actigraphy data for which no corresponding diary data are available. With an adult population, Boudebesse et al. (2013) compared a no-diary condition with a diary condition, however only by looking at group-level average differences, which limits the conclusions that can be drawn. In what appears to be the only relevant study with a pediatric population, Meltzer and Westin (2011) evaluated the impact of using or not using a sleep diary to derive sleep actigraphy variables with the Micro Motionlogger Sleep Watch (Ambulatory Monitoring Inc.) and the Sadeh scoring algorithm. They concluded that while a sleep diary is essential to identify artifacts in actigraphic data, it may be possible to include one or two nights for which diary data are not available. They also indicated that additional research was necessary to examine scoring procedures using other devices and algorithms. To our knowledge, such additional research has yet to be conducted. Doing so is an important endeavor considering the increasing number of studies that use actigraphy to assess children's sleep, and the amount of data that can be lost due to failure to complete the sleep diary (e.g., Acebo et al., 1999).

Accordingly, the current study addressed the same question as Meltzer and Westin (2011), while benefiting from a larger sample (60 children, vs. 38) and using a different actigraphy device and algorithm (see section 2.3.1), which may lead to different conclusions (e.g., Meltzer, Walsh, et al., 2012). The aim of the current analyses was to compare two conditions of actigraphy scoring: a first condition in which the scoring of actigraphic data was guided by a parent diary, and a second condition in which the actigraphic data were scored without any use of a diary.

We also aimed to enrich the information drawn from the data in two ways. First, to estimate the degree of convergence between sleep estimates derived with and without the use of a diary for scoring, we used intraclass correlations (ICC) instead of Pearson's correlations. Like Pearson's correlations, ICC indicate the degree of relation between individuals' rank order on two measures (in this case, the two scoring conditions), however, ICC have the unique advantage of also considering systematic differences between measures (Brouwer et al., 2004; Weir, 2005 – more detail in section 2.5). Furthermore, we complemented the analyses with the Bland and Altman method (1999). In contrast to other statistical analyses (e.g., correlations examining degree of convergence, analysis of variance estimating mean-level differences), this procedure does not focus on between-children differences but rather estimates the agreement between methods on a child-by-child basis. This yields unique information that is masked by analyses based on measures of central tendency, notably the number of cases for which the discrepancy between two measures exceeds a pre-determined threshold considered to be meaningful. For this reason, Werner et al. (2008) stated that the Bland and Altman method constitutes the only appropriate approach to examine the agreement between two measures. In addition, such an analytic method may be uniquely informative in a clinical sense, owing to its focus on specific children's data points. Accordingly, we used this method to conduct a child-by-child examination of the agreement between actigraphic data scored with and without a sleep diary.

2. Method

2.1 Participants

Sixty typically-developing children (36 girls) aged between 6 and 10 years old participated in this study. In order to obtain a diverse and balanced age range, children were sampled into five equal groups, each corresponding to a distinct school level: first grade (M = 7.05 years; n = 12; 7 girls), second grade (M = 7.74 years; n = 12; 7 girls), third grade (M = 8.66 years; n = 12; 7 girls), fourth grade (*M* = 9.79 years; n = 12; 7 girls), and fifth grade (*M* = 10.54 years; n = 12; 8 girls). Families were part of a larger study and were recruited from birth lists randomly generated and provided by the Ministry of Health and Social Services. Written informed consent was obtained from parents prior to the beginning of the study. The study protocol was approved by the university's institutional review board. Criteria for participation were full-term pregnancy and the absence of any known physical and mental disability in the child. Most parents were Caucasian (80% of mothers, 75% of fathers). Mothers were between 20 and 45 years old (*M* = 31) and had 14.65 years of education on average. Fathers were between 22 and 48 years old (*M* = 33) and had 14.89 years of education on average. Family income varied from less than $20,000 CDN to over $100,000 CDN, with an average in the $60,000 to $79,000 bracket.

2.2 Procedure

At the end of a home visit, a research assistant left an actigraph and a sleep diary with the family and provided instructions concerning these two measures. Children put on the actigraph when they went to bed and removed it when they got up the next morning. They wore the actigraph on their non-dominant wrist for three (first and second grades) or seven (third to fifth grades) consecutive nights, and mothers were asked to complete a diary of their child's sleep during the same period. The three-night period with the younger children was chosen with the aim of reducing child and family burden and thus optimizing compliance. Although Acebo et al. (1999) recommended the use of at least five nights of actigraphy recordings to obtain optimally reliable measures, one notes from closer inspection of their data that satisfactory levels of reliability (close or superior to .70) can obtained with three days of assessment, which also guided our choice. More nights of assessment were nonetheless later added (third grade on), as children matured and were more amenable to wearing the actigraph for a full week while being able to remember to take it off for bathing and swimming, which reduced parents' burden. Following the period of actigraphy assessment, the assistant returned to the family's home to retrieve the actigraph and the diary, and provided financial compensation to the family (CND$20 when the actigraph was worn for three nights and CND$30 for seven nights). Actigraphic data were then downloaded to a computer immediately upon returning to the laboratory.

2.3 Measures

2.3.1 Actigraphy

Children wore an AW-2 Actiwatch (Mini-Mitter, Philips Respironics, Bend, OR). Data were collected using the proportional integration mode (PIM) and scored using Actiware software version 6.0.9 (Philips Respironics, Bend, OR). The automated manufacturer's low sensitivity threshold algorithm (80 activity counts per epoch) was used to analyze data. This sensitivity threshold is frequently used to assess school-aged children's sleep (Meltzer, Walsh, & Peightal, 2015; Meltzer, Walsh, et al., 2012; Spruyt et al., 2011) and is well-suited to their enhanced motor activity during sleep (de Koninck, Lorrain, & Gagnon, 1992). Moreover, the AW-2 device, when used with this algorithm among children (aged 3 to 18 years; *M* = 8.8 years), shows good sensitivity (to detect sleep; 89%) and poorer but acceptable specificity (to detect wake; 77%) when compared with PSG estimates (Meltzer, Walsh, et al., 2012). Although non-optimal, this level of specificity is comparable to or higher than that obtained with other devices (e.g., Motionlogger Sleep Watch — Ambulatory Monitoring Inc.) and algorithms (e.g., Sadeh, Cole-Kripke, and high or medium sensitivity threshold algorithms), again with children from 3 to 18 years (see Meltzer, Walsh, et al., 2012). Although several actigraphy devices have an event marker that can be pressed by the participant to indicate bedtime and waketime, event markers were not used in the current study, given that they also often yield much missing data (e.g., nearly 30% of participants failed to press the event marker at sleep onset or offset in the study by Meltzer & Westin, 2011). This allowed us to investigate the validity of actigraphy data when scored without any supplemental information, whether from a diary or event marker. Data were collected in 30-s epochs. All first and second graders had three nights of valid sleep data. For third, fourth, and fifth graders, valid sleep data were available for seven nights for 20 participants, six nights for 11 participants, five nights for 1 participant, and four nights for 4 participants. Missing data were attributable to children's refusal or failure to wear the actigraph. Sleep diary data were available in all cases.

Sleep values were averaged across all nights available for each participant. Actigraphy-derived sleep variables were (a) nocturnal sleep duration, (b) nocturnal wake duration, and (c) sleep efficiency. Sleep onset and offset were determined as explained below.

2.3.2 Sleep diary

On the days when children wore the actigraph, their mothers completed a daily sleep diary (one diary by assessment period; i.e., period of three or seven days). Different sleep variables can be obtained from the diary (e.g., sleep duration, night awakenings perceived by the parent), but in the current study, the diary was used exclusively as an aid in scoring actigraphy data. For the first and second grade groups (in which children wore the actigraph for three nights), the diary consisted of a 24-hour timeline on which mothers indicated, for each half hour, whether their child was awake or asleep, and where he or she slept (e.g., child bedroom, car, etc.). Mothers were also asked to note the moments where the child did not wear the actigraph, as well as any event that might have disturbed the child's sleep, such as illness, holidays, or visitors staying late at home. With this diary, sleep onset (used to score the actigraphy data) corresponded to the time at which the mother noted the beginning of the first half hour of nighttime sleep, and sleep offset corresponded to the end of the last half hour of sleep, again as indicated by the mother. For the third to fifth grade groups (in which children wore the actigraph for seven nights), the diary consisted of a questionnaire on which the mother indicated, for each night of assessment, the time at which the child went to bed and the time he or she got up the next morning. With this diary, sleep onset corresponded to the time at which the mother indicated that the child went to sleep, and sleep offset corresponded to the time at which the mother indicated that the child got up the next morning. Mothers were also asked to note the moments where the child did not wear the actigraph and any event that might have disturbed his or her sleep.

2.4 Actigraphy scoring

For each participant, the two conditions (with and without diary) were rated independently by two different trained research assistants who were experienced with actigraphy data scoring. Each assistant was randomly assigned 50% of the actograms to score in each condition, with and without diary. For each age group, the first assistant scored 50% of the cases with the diary, and the other 50% without the diary. The second assistant did the exact opposite. Hence, each assistant scored a child's sleep only once, either with or without the diary (as they were never in charge of the same case in the two conditions), and the two assistants never scored the same child's data within the same condition. In order to score the data without any other cue (except the diary in the diary condition), the light indicator was removed from the actogram.

2.4.1 Diary condition

To determine sleep onset in the diary condition, the research assistant started examination of the actogram at 30 minutes prior to sleep onset indicated on the diary. Then, the assistant moved forward in the actogram from this starting point and manually defined sleep onset as the start of the first ten consecutive minutes of sleep (i.e., the first twenty 30-s periods for which the activity count was at or near zero). To determine sleep offset, the starting point was set 30 minutes after sleep offset indicated on the diary, and the research assistant moved backward in time from that point to define sleep offset as the end of the last ten consecutive minutes of sleep identified in the actogram. The 10-minute scoring rule is frequently used in pediatric sleep research (e.g., Kieckhefer, Ward, Tsai, & Lentz, 2008; Spruyt et al., 2011; Van der Heijden, Smits, & Gunning, 2006).

2.4.2 Without diary condition

In this condition, the diary was not used to score actigraphic data. In order to standardize the scoring of the two conditions and to avoid subjective judgment, the 10-minute scoring rule was also applied in this condition. Sleep onset was set at the beginning of the first ten consecutive minutes of sleep visually identified in the actogram (i.e., the first twenty 30-s periods for which the activity count was at or near zero) and sleep offset, at the end of the last ten consecutive minutes of sleep.

2.5 Data analysis

All statistical analyses were conducted using SPSS version 24 (SPSS Inc., Chicago, IL). For each sleep variable, we first averaged the nights available for each participant and conducted analyses of mean-level differences. We then computed intraclass correlations (ICC) for each sleep variable to estimate the degree of convergence between the diary and no-diary conditions. While Pearson's correlation (r) only measures the degree of association between two variables, ICC are designed to assess consistency or conformity between two measures or conditions. In fact, with Pearson's r, any two measures may be highly (or even perfectly) correlated, and still differ systematically, as long as both measures increase or decrease at the same proportional rate. In contrast, ICC assess not only the strength of association, but also whether the measures differ systematically (Brouwer et al., 2004; Weir, 2005). Suppose that each child's rank order relative to other children on sleep duration is the same across the two scoring conditions, but that the no-diary condition systematically yields higher (or lower) estimates of sleep duration than the diary condition, even by just a few minutes. This would yield a perfect (1.00) Pearson's r, but a lower ICC, because ICC takes into account the systematic difference between the two measures. In contrast, if the difference between the two measures is random (with sleep duration sometimes higher with the diary, sometimes lower), then the ICC will be higher. Because an ICC is a correlation, it can vary from -1 to +1 and be interpreted like a Pearson's r.

In addition, the statistical approach proposed by Bland and Altman (1999) was used to assess the rate of agreement between diary- and without-diary-derived sleep variables. This approach allows for visual representation of agreement and differences between two measures or conditions by plotting them against each other. Bland-Altman limits of agreement for each variable are computed using mean and standard deviation of the differences between the two conditions. The recommended criterion to consider that two measures are interchangeable is that 95% of the data points lie within two standard deviations of the mean difference (limits of agreement = ±1.96*standard deviation). The data are graphed in a scatter plot with the Y axis presenting the difference between the two conditions (A-B) and the X axis the average of these measures ((A+B)/2).

3. Results

Descriptive statistics for the two conditions are shown in Table 1. For both conditions, sleep values were comparable to those obtained in prior studies using actigraphy with school-aged children (El-Sheikh, Kelly, Buckhalt, & Hinnant, 2010; Sadeh, Raviv, & Gruber, 2000). Two-way ANOVAs with sex and age group (first, second, third, fourth and fifth grades) as factors were performed on each sleep variable (sleep duration, wake duration, and efficiency; each in both conditions — with and without diary) and showed that there were no significant sex or age differences (or interactions) on any sleep variable (all *p*s >.11). Moreover, t-tests showed that there were no significant differences according to the type of diary (that used for first and second grades or that used for third to fifth grades); all *p*s >.06.

Table 1 shows that differences between sleep estimates derived with and without the sleep diary were extremely small on average: compared to the diary condition, the without-diary condition underestimated sleep duration by 1.01 minute per night and wake duration by 0.76 minute, and overestimated sleep efficiency by 0.11%. Nonetheless, t-tests were run between diary and no-diary conditions for each sleep variable and revealed that two differences were statistically significant (for wake duration, $p = .03$ and sleep efficiency, $p < .001$). Closer inspection of the data revealed that the differences between conditions, albeit very small in magnitude, were statistically significant because relatively systematic in direction: in 55/60 cases, sleep efficiency was higher when assessed without than with a diary, and wake duration was lower when assessed without than with a diary in 46/60 cases. These differences were further probed with the Bland-Altman analyses presented below. Intraclass correlation coefficients between the two conditions were very high (Landis & Koch, 1977) for all three sleep variables: ICC = .96 (sleep duration), .97 (wake duration) and .98 (sleep efficiency), all *p*s < .001.

Bland-Altman plots of the difference against the mean for all sleep estimates are presented in Figures 1 to 3. The mean differences obtained were normally distributed. In all three figures, circles represent children from the first and second grades group, and squares represent those from the third to fifth grades group, thus differentiating results obtained with the two different diaries. Figure 1 illustrates a comparison of total nightly sleep duration derived by the diary and without-diary conditions. Here, the mean difference between the two conditions was 1 min per night [95% confidence interval: –55 s to +2 min 56 s]. Also, the difference in sleep duration for 90% of the children was between the limits of agreement, which were -13 min 32 s and 15 min 33 s. Similar results were found for wake duration as presented in Figure 2. The mean difference was 45 s [95% confidence interval 1 s to 1 min 25 s]. The limits of agreement were -4 min 16 s and 5 min 46 s and the difference in wake duration for 93% of the children was between these limits. Finally, Figure 3 shows a comparison of sleep efficiency measured by the diary and without-diary conditions. The mean difference was -.11% [95% confidence interval -.20% to -.02%]. The limits of agreement were between -0.80% and 0.59% and the difference in sleep efficiency for 93% of the children was between these limits. These 90% to 93% rates, while high, failed to meet the criterion that 95% of data must be within the agreement limits in order to confirm that two assessment conditions are *interchangeable* (Bland & Altman, 1999). However, for all children, the difference between the two conditions was less than 29 minutes for sleep duration, less than 14 minutes for wake duration, and less than 2% for sleep efficiency. Furthermore, inspection of the plots shows that the vast majority of difference scores were not only within the limits of agreements, but in fact quite tightly distributed near the mean difference, which was very close to zero. The gaps between the two conditions were therefore quite small, even when analyzed on a child-by-child basis. The difference scores also did not appear to vary systematically with the mean scores, indicating that the discrepancy between the two measures was not related to mean levels of sleep duration, wake duration, or sleep efficiency. Finally, the plots indicate that outliers were not more likely to come from the use of one specific type of diary.

4. Discussion

The aim of the current study was to investigate whether children's sleep and wake periods can be identified accurately with actigraphy when parents fail to complete a sleep diary. Sleep estimates derived from scoring the same actigraphic recordings with and without the support of a parental sleep diary were compared. To our knowledge, this is the first study to investigate this question with the AW-2 Actiwatch. Moreover, the chosen analyses allowed for the first investigation (to our knowledge) of the agreement between those scoring conditions not only at a group level, but also and importantly on a child-by-child basis.

The traditional group-level approach revealed very small differences between the two scoring conditions: the overall mean differences were 1.01 minute per night for sleep duration, 0.76 minute for wake duration, and 0.11% for sleep efficiency. Yet, these differences were statistically significant for both wake duration and sleep efficiency. As explained above, this was due to the relatively systematic *direction* of differences between scoring methods, which made for very small yet statistically reliable differences. The intraclass correlations were extremely high (Landis & Koch, 1977), varying from .96 to .98, indicating that children's rank-order on all sleep parameters is virtually identical across the two scoring conditions.

The Bland-Altman analyses, which have not been used before to address such questions, revealed a more nuanced picture. Given the proportion (7-10%) of outliers whose values lied outside the limits of agreement, the data failed to demonstrate that the two conditions were *interchangeable* (Bland & Altman, 1999). However, for all children, the difference between the two conditions were quite small (less than 29 minutes for sleep duration, less than 14 minutes for wake duration, and less than 2% for sleep efficiency). Accordingly, the results suggest that the two conditions yield quite similar (albeit not interchangeable) results, even when analyzed on a child-by-child basis. In addition, the plots indicate that for a vast majority of children, the discrepancy between the two measures is much smaller, and this is so regardless of their sleep duration, efficiency, or wake duration.

Studies that assess children's sleep using actigraphy are generally mostly concerned with inter-individual differences, and the high intraclass correlations found in the current study show that, to this end, the two conditions (with and without diary) provide extremely similar results. In contrast, if one aimed to assess individual children's exact sleep or wake duration, for instance to establish precise norms or for clinical purposes, the small gap between the two conditions found in this study could justify the rejection of actigraphy data not corroborated by a sleep diary. Likewise, in sleep intervention studies using pre- and post-treatment sleep measures, the use of a sleep diary only at pre- or post-treatment could introduce some unwanted error likely to mask *or* inflate treatment effects. However, the current findings suggest that such error is likely to be small in magnitude in most cases.

Overall, the current analyses show a large degree of agreement between the two conditions, suggesting that it is possible to include some nights' or some participants' actigraphy data for which no corresponding diary data are available. The results are in line with those found by Meltzer and Westin (2011) using a different actigraph device and a different algorithm, also with school-aged children. However, we agree with Meltzer and Westin (2011) that analyzing child actigraphy data in the absence of a parental diary should be done with care. First, the diary contains relevant information for scoring, such as the approximate time when the child went to bed and woke up the next morning, which helps determine sleep onset and offset times from the actogram. Second, when scoring actigraphy data without a diary, potential errors remain, due for instance to artifacts that would not be detected in actigraphy data (e.g., a participant who removed the actigraph during the night or was sleeping in a car). On the other hand, discarding participants or specific nights on the basis of the parent's failure to fill out the sleep diary may lead to a non-negligible amount of lost data, especially due to the need to exclude participants who have fewer than a pre-specified number of scorable nights (e.g., five nights; Acebo et al., 1999). This may potentially result in decreased statistical power, as well as in a non-random bias inherent to certain participants' or nights' characteristics. We therefore recommend that researchers continue to ask parents to complete a sleep diary while their child is wearing the actigraph, bearing in mind that if necessary, modest amounts of actigraphic data that are not complemented by a diary can be scored validly and thus be included, especially in analyses of individual differences.

In the current study, the event marker was not used. However, it is worth noting that when available, the event marker constitutes a good replacement for the diary with respect to identification of sleep onset and offset. It must also be noted that when faced with actigraphy data not accompanied by any other information (diary, event marker, light indicator), some sleep variables may be impossible to assess (e.g., sleep onset latency, which was accordingly not considered in the current study).

The current study presents limitations that need to be considered when interpreting the results. First, the use of a low-risk and relatively small sample may have diminished variability in sleep patterns and led to low rates of children with sleep problems, making the results less generalizable to samples presenting with greater medical or psychosocial risk. In addition, some subjects had only three or four nights of sleep data, which contributes to reducing the amount of data analyzed and thus limits the chances of encountering particular situations that may jeopardize the validity of the sleep data, such as participants removing the actigraph.

5. Conclusions

The current report suggests that when studying typically-developing school-age children, it is possible to use a modest amount of actigraphy data not supplemented by a sleep diary, especially when conducting individual differences analyses. Yet, more studies, especially with clinical or high-risk populations, are necessary to further corroborate this suggestion and test its generalizability.

References

Acebo, C., Sadeh, A., Seifer, R., Tzischinsky, O., Wolfson, A. R., Hafer, A., & Carskadon, M. A. (1999). Estimating sleep patterns with activity monitoring in children and adolescents: How many nights are necessary for reliable measures? *Sleep*, *22*, 95-103. Retrieved from http://europepmc.org/abstract/ med/9989370

Bélanger, M. È., Bernier, A., Paquet, J., Simard, V., & Carrier, J. (2013). Validating actigraphy as a measure of sleep for preschool children. *Journal of Clinical Sleep, 9*, 701-706. doi:10.5664/jcsm.2844

Bélanger, M. È., Bernier, A., Simard, V., Bordeleau, S., & Carrier, J. (2015). Attachment and sleep among toddlers: Disentangling attachment security and dependency. *Monographs of the Society for Research in Child Development, 80,* 125-140. doi:10.1111/mono.12148

Bélanger, M. È., Bernier, A., Simard, V., Desrosiers, K., & Carrier, J. (2016). Sleeping toward behavioral regulation: Relations between sleep and externalizing symptoms in toddlers and preschoolers. *Journal of Clinical Child & Adolescent Psychology*. Advance online publication. doi:10.1080/15374416.2015.1079782

Berger, A. M., Wielgus, K. K., Young-McCaughan, S., Fischer, P., Farr, L., & Lee, K. A. (2008). Methodological challenges when using actigraphy in research. *Journal of Pain and Symptom Management, 36*, 191-199. doi:10.1016/j.jpainsymman.2007.10.008

Bernier, A., Beauchamp, M. H., Bouvette-Turcot, A. A., Carlson, S. M., & Carrier, J. (2013). Sleep and cognition in preschool years: Specific links to executive functioning. *Child Development, 84*, 1542-1553. doi:10.1111/cdev.12063

Bland, J. M., & Altman, D. G. (1999). Measuring agreement in method comparisonstudies. *Statistical Methods in Medical Research*, *8*, 135-160. doi:10.1177 /096228029900800204

Boudebesse, C., Leboyer, M., Begley, A., Wood, A., Miewald, J., Hall, M., ... & Germain, A. (2013). Comparison of five actigraphy scoring methods with bipolar disorder. *Behavioral Sleep Medicine, 11,* 275-282. doi:10.1080/15402002.2012.685997

Brouwer, S., Kuijer, W., Dijkstra, P. U., Göeken, L. N., Groothoff, J. W., & Geertzen, J. H. (2004). Reliability and stability of the Roland Morris Disability Questionnaire: Intra class correlation and limits of agreement. *Disability and Rehabilitation, 26*, 162-165. doi:10.1080/09638280310001639713

de Koninck, J., Lorrain, D., & Gagnon, P. (1992). Sleep positions and position shifts in five age groups: An ontogenetic picture. *Sleep: Journal of Sleep Research & Sleep Medicine*, *15*, 143-149. doi:10.1093/sleep/15.2.143

El-Sheikh, M., Kelly, R. J., Buckhalt, J. A., & Hinnant, J. B. (2010). Children's sleep and adjustment over time: The role of socioeconomic context. *Child Development, 81*, 870-883. doi:10.1111/j.1467-8624.2010.01439.x

Gregory, A. M., Caspi, A., Eley, T. C., Moffitt, T. E., O'Connor, T. G., & Poulton, R. (2005). Prospective longitudinal associations between persistent sleep problems in childhood and anxiety and depression disorders in adulthood. *Journal of Abnormal Child Psychology, 33,* 157-163. doi:10.1007/s10802-005-1824-0

Kieckhefer, G. M., Ward, T. M., Tsai, S. Y., & Lentz, M. J. (2008). Nighttime sleep and daytime nap patterns in school age children with and without asthma. *Journal of Developmental and Behavioral Pediatrics*, *29*, 338-344. doi:10.1097/DBP.0b013e318182a99e

Landis, J. R., & Koch, G. G. (1977). The measurement of observer agreement for categorical data. *Biometrics,* 33, 159-174. doi:10.2307/2529310

Lavigne, J. V., Arend, R., Rosenbaum, D., Smith, A., Weissbluth, M., Binns, H. J., & Christoffel, K. K. (1999). Sleep and behavior problems among preschoolers. *Journal of Developmental and Behavioral Pediatrics, 20,* 164-169. doi:10.1097/ 000047

Meltzer, L. J., Montgomery-Downs, H. E., Insana, S. P., & Walsh, C. M. (2012). Use of actigraphy for assessment in pediatric sleep research. *Sleep Medicine Reviews*, *16*, 463-475. doi:10.1016/j.smrv.2011.10.002

Meltzer, L. J., Walsh, C. M., & Peightal, A. A. (2015). Comparison of actigraphy immobility rules with polysomnographic sleep onset latency in children and adolescents. *Sleep and Breathing, 19*, 1415-1423. doi:10.1007/s11325-015-1138-6

Meltzer, L. J., Walsh, C. M., Traylor, J., & Westin, A. M. (2012). Direct comparison of two new actigraphs and polysomnography in children and adolescents. *Sleep, 35*, 159-166. doi:10.5665/sleep.1608

Meltzer, L. J., & Westin, A. M. (2011). A comparison of actigraphy scoring rules used in pediatric research. *Sleep Medicine, 12,* 793-796. doi:10.1016/j.sleep.2011.03.011Mindell, J. A., & Owens, J. A. (2010). Evaluation of pediatric sleep disorders. In J.A. Mindell, & J.A. Owens (Eds.). *A clinical guide to pediatric sleep. Diagnosis and management of sleep problems*, (2nd ed., pp. 30-42). Philadelphia, PA: Lippincott.

Reilly, J. J., Armstrong, J. Dorosty, A. R., Emmett, P. M., Ness, A., Rogers, I., . . . for the Avon Longitudinal Study of Parents and Children Study Team (2005). Early life risk factors for obesity in childhood: Cohort study. *British Medical Journal, 330*, 1357–1363. doi:10.1136/bmj.38470.670903.E0

Sadeh, A. (2011). The role and validity of actigraphy in sleep medicine: An update. *Sleep Medicine Reviews, 15*, 259-267. doi:10.1016/j.smrv.2010.10.001

Sadeh, A. (2015). Sleep assessment methods. *Monographs of the Society for Research in Child Development, 80*, 33-48. doi:10.1111/mono.12143

Sadeh, A., Lavie, P., Scher, A., Tirosh, E., & Epstein, R. (1991). Actigraphic home-monitoring sleep-disturbed and control infants and young children: A new method for pediatric assessment of sleep-wake patterns. *Pediatrics, 87*, 494-499. Retrieved from http://pediatrics.aappublications.org/content/pediatrics/87/4/494.full.pdf

Sadeh, A., Raviv, A., & Gruber, R. (2000). Sleep patterns and sleep disruptions in school-age children. *Developmental Psychology*, *36*, 291-301. doi:10.1037/0012-1649.36.3.291

Sitnick, S. L., Goodlin-Jones, B. L., & Anders, T. F. (2008). The use of actigraphy to study sleep disorders in preschoolers: Some concerns about detection of nighttime awakenings. *Sleep*, *31*, 395-401. Retrieved from http://www.ncbi.nlm.nih.gov /pmc/articles/PMC2276752/

Spruyt, K., Gozal, D., Dayyat, E., Roman, A., & Molfese, D. L. (2011). Sleep assessments in healthy school-aged children using actigraphy: Concordance with polysomnography. *Journal of Sleep Research, 20*, 223-232. doi:10.1111/j.1365-2869.2010.00857.x

Thome, M., & Skuladottir, A. (2005). Changes in sleep problems, parents distress and impact of sleep problems from infancy to preschool age for referred and unreferred children. *Scandinavian Journal of Caring Sciences, 19*, 86–94. doi:10.1111/j.1471-6712.2005 .00322.x

Van der Heijden KB, Smits MG, Gunning WB (2006). Sleep hygiene and actigraphically evaluated sleep characteristics in children with ADHD and chronic sleep onset insomnia. *Journal of Sleep Research, 15*, 55-62. doi:10.1111/j.1365-2869.2006.00491.x

Weir, J. P. (2005). Quantifying test-retest reliability using the intraclass correlation coefficient and the SEM. *Journal of Strength and Conditioning Research, 19*, 231-240. doi:10.1519 /15184.1

Werner, H., Molinari, L., Guyer, C., & Jenni, O. G. (2008). Agreement rates between actigraphy, diary, and questionnaire for children's sleep patterns. *Archives of Pediatrics & Adolescent Medicine, 162*, 350-358. doi:10.1001/archpedi.162.4.350

Table 1

Descriptive statistics of sleep variables

Sleep variables	Min	Max	Mean	SD
Diary				
Sleep duration (min)	466.50	597.29	533.32	27.38
Wake duration (min)	9.79	64.50	32.50	10.63
Sleep efficiency (%)	89.42	98.17	94.27	1.80
Without diary				
Sleep duration (min)	466.75	581.86	532.31	25.89
Wake duration (min)	9.79	64.50	31.74	10.22
Sleep efficiency (%)	89.41	98.17	94.38	1.76

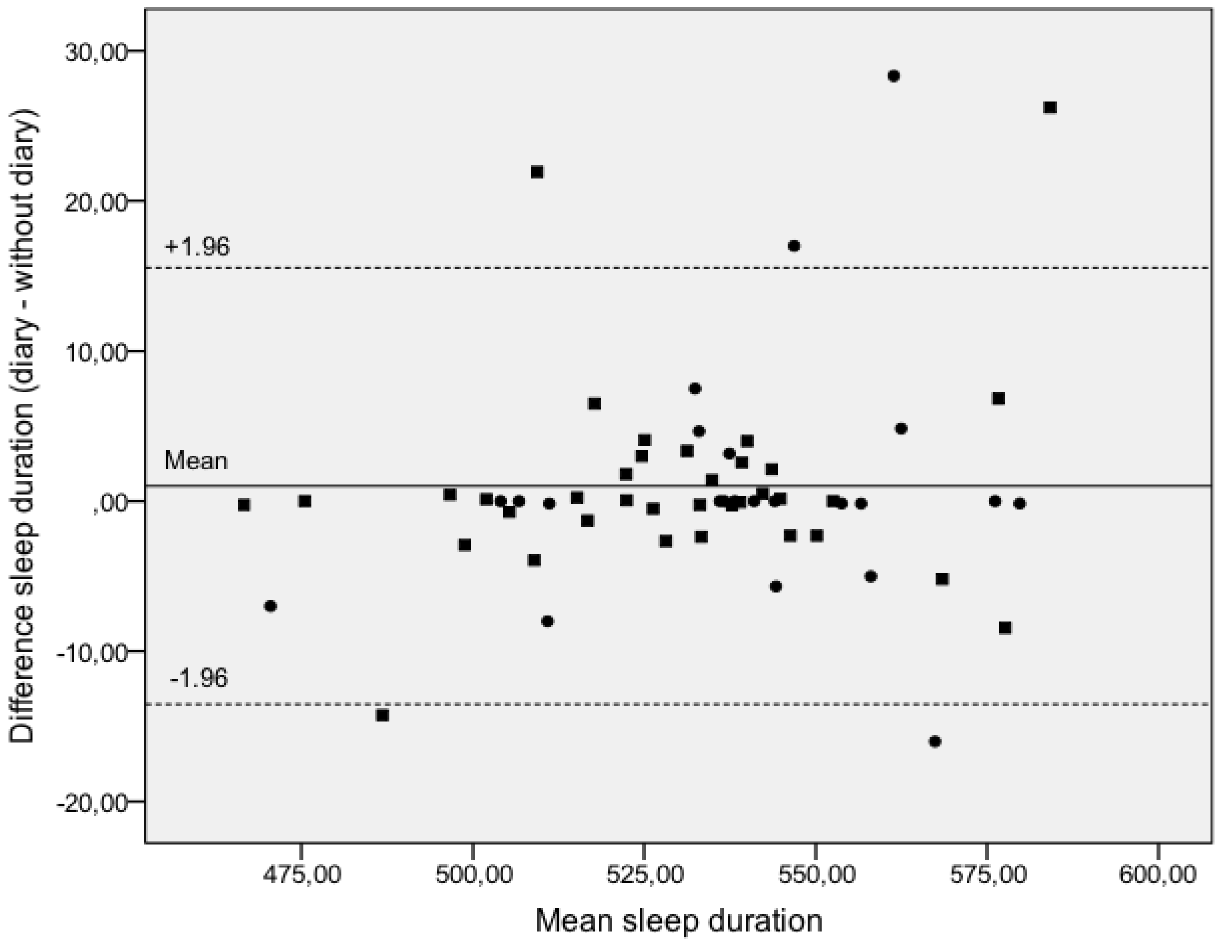

Figure 1. Plot of difference against mean for sleep duration. Circles represent children from the first and second grades group (the first diary), and squares represent those from third to fifth grades group (the second diary).

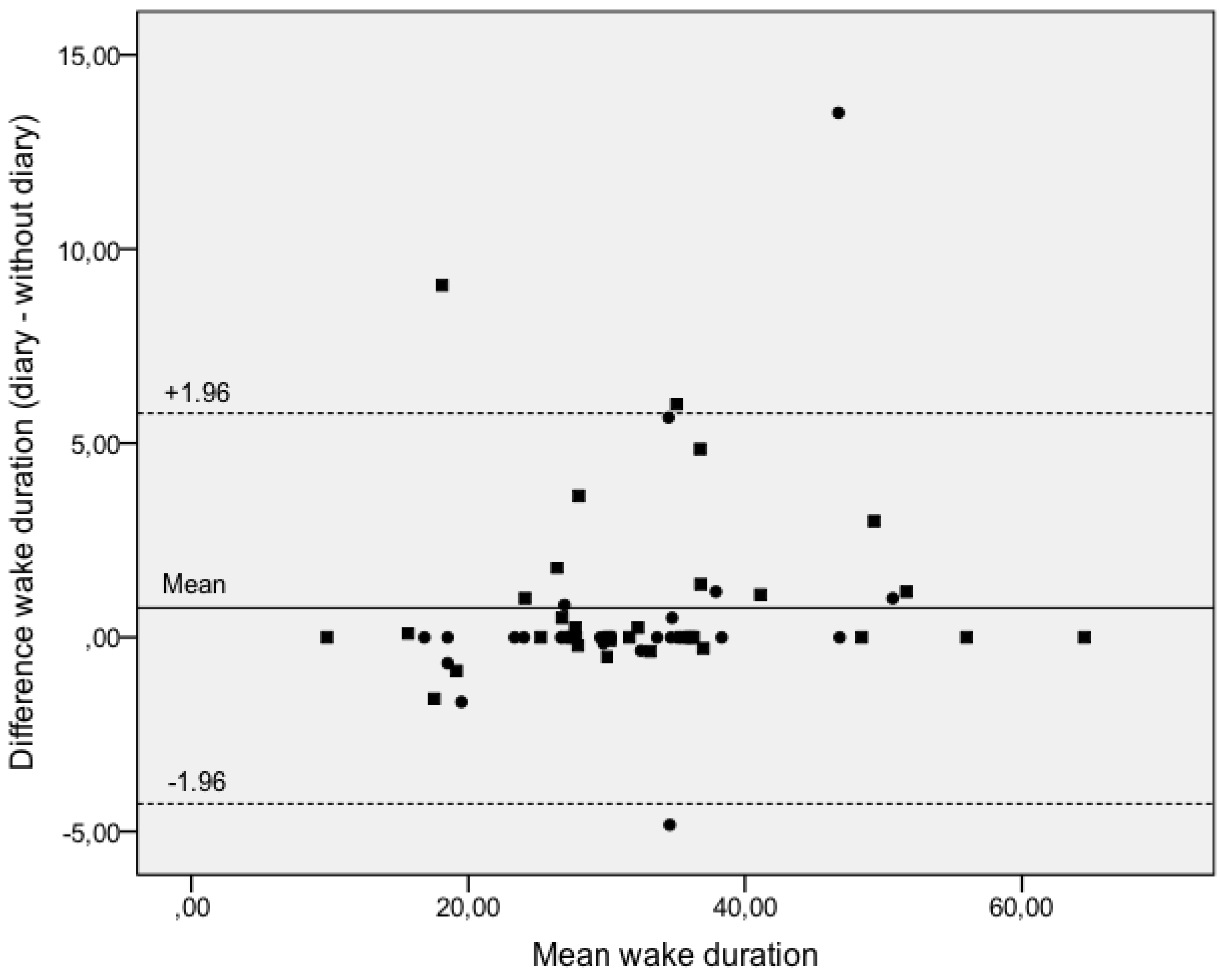

Figure 2. Plot of difference against mean for wake duration. Circles represent children from the first and second grades group (the first diary), and squares represent those from third to fifth grades group (the second diary).

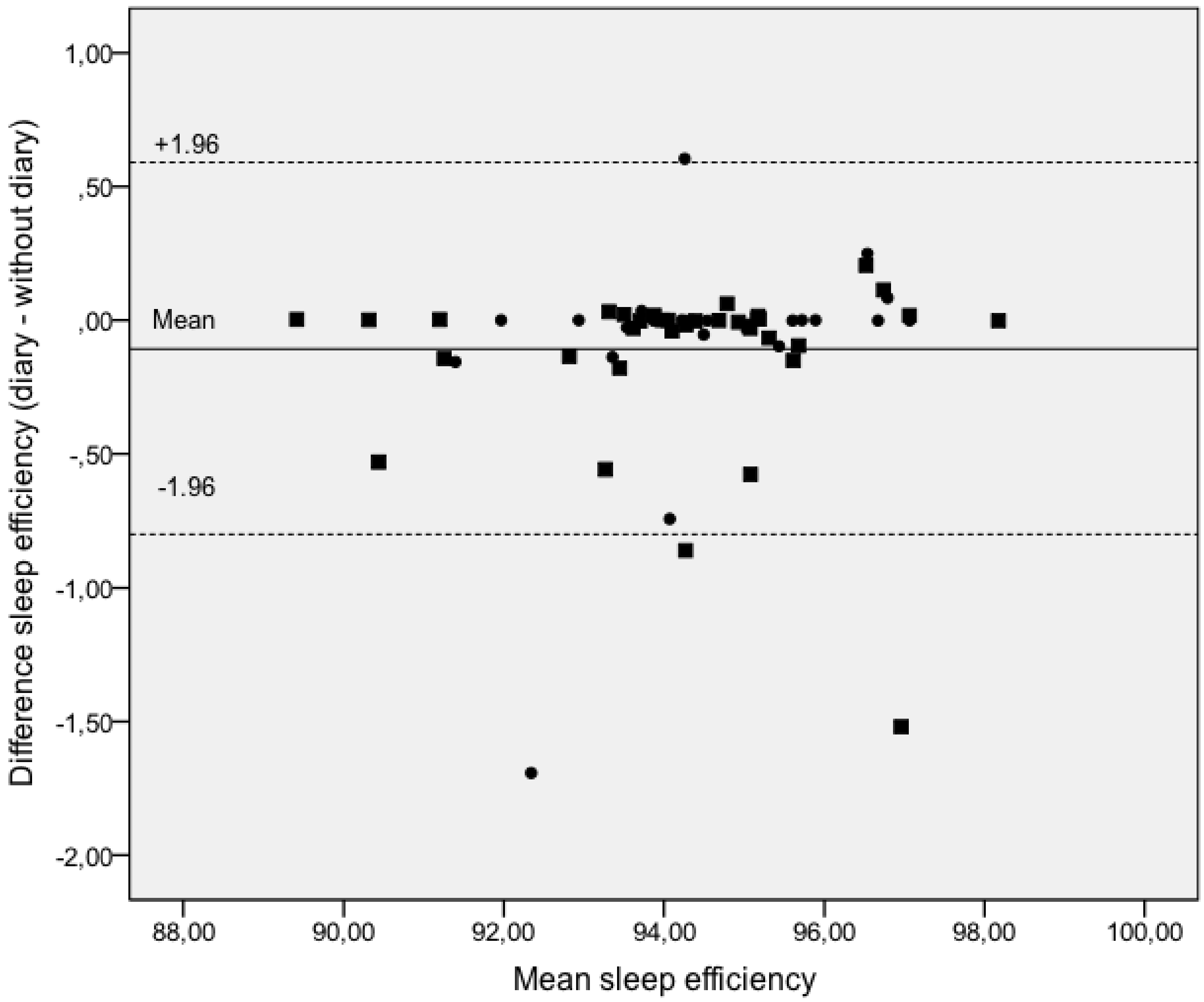

Figure 3. Plot of difference against mean for sleep efficiency. Circles represent children from the first and second grades group (the first diary), and squares represent those from third to fifth grades group (the second diary).

Article 2

Normative developmental trajectories of actigraphic sleep variables during the preschool period: A three-wave longitudinal study

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Normative developmental trajectories of actigraphic sleep variables during the preschool period: A three-wave longitudinal study

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Abstract

Important changes in sleep are believed to occur in the preschool years, but studies that have documented these changes were generally cross-sectional or based on subjective sleep measures. The current longitudinal study modeled the developmental trajectories followed by five sleep variables objectively assessed during the preschool period. Children (N = 128) wore an actigraph over three days at 2, 3, and 4 years of age and change in sleep variables was assessed with growth curves. The results showed a linear decrease of daytime, total, and nighttime sleep duration, and a linear increase of sleep efficiency and proportion of nighttime to total sleep. For all sleep variables, the rhythm of change was relatively uniform across children, but there was significant inter-individual variation around the initial status for most variables. To our knowledge, this study is the first to model the developmental trajectories followed by several sleep variables during the preschool period.

Keywords: child sleep, development, longitudinal, preschool, actigraphy

Normative developmental trajectories of actigraphic sleep variables during the preschool period: A three-wave longitudinal study

During childhood, healthy development requires sleep of sufficient quantity and quality (El-Sheikh & Sadeh, 2015). Unfortunately, sleep problems are frequent among children (Mindell & Owens, 2015) and may have negative consequences on school adjustment (Williams, Nicholson, Walker, & Berthelsen, 2016), cognition (Bernier, Beauchamp, Bouvette-Turcot, Carlson, & Carrier, 2013) and on emotional (Miller, Seifer, Crossin, & Lebourgeois, 2015) and behavioral (Bélanger, Bernier, Simard, Desrosiers, & Carrier, 2018) regulation. Moreover, sleep problems often persist throughout childhood (Mindell & Owens, 2015) and predict emotional and learning difficulties in adolescence (Silva et al., 2011). Hence, early identification of children experiencing sleep difficulties is important for prompt intervention. In order to identify children with sleep problems, knowledge about the normative development of sleep is necessary.

Normative sleep at preschool age

It is generally accepted that the preschool period is characterized by a decrease in the duration of daytime sleep and total 24-hour sleep (see Galland et al., 2012 for a review of studies using subjective measures). Parents report that their children sleep an average of about 14 hours at 2 years and 12 hours at 4 years (Iglowstein, Jenni, Molinari, & Largo, 2003; Jenni, Molinari, Caflisch, & Largo, 2007). Naps usually correspond to a total of 90 to 110 minutes of daytime sleep during the preschool period (Iglowstein et al., 2003). However, nap duration decreases between ages 2 and 4, both as measured objectively by actigraphy (Acebo et al., 2005; Ward, Gay, Anders, Alkon, & Lee, 2008) and as reported by parents (Iglowstein et al., 2003). Nighttime sleep duration remains relatively stable across the preschool years, with an average of 10 hours of nocturnal sleep (according to both actigraphy and parent reports; see Mindell & Owens, 2015 – although some cross-sectional studies suggest a small decrease of nighttime sleep duration during this period: Acebo et al., 2005; Ward et al., 2008). Moreover, sleep becomes increasingly concentrated during the night period (see Davis et al., 2004; Sheldon, 2006 for reviews), as growing proportions of total sleep take place at night, from about 85% at 2 years to 97% at 4 years according to both actigraphy and parent reports (Acebo et al., 2005; Iglowstein et al., 2003).

Less is known about indicators of sleep quality in the preschool period, such as awakenings and efficiency. Jenni, Fuhrer, Iglowstein, Molinari, and Largo (2005) found that nighttime awakenings remain frequent: 22% of parents reported that their child woke up at least once every night at 2 years and 54% at least once a week at 4 years. However, the duration of awakenings tends to diminish after infancy, from an average of 2 hours at 1 year to a maximum of 82 minutes between 2 and 4 years (Acebo et al., 2005). Consequently, sleep efficiency (the percentage of time spent asleep between sleep onset and morning awakening) tends to increase, from an average of 81% at 1 year to averages between 86% and 93% during preschool years (Acebo et al., 2005; Scholle et al., 2011 using polysomnography; Ward et al., 2008).

Developmental patterns of change in sleep

The research presented above provides estimates of average values of different sleep variables at different ages. Importantly, however, conclusions about “increases” and “decreases” in different sleep variables are often drawn based on comparisons of mean-level estimates obtained across studies that examined children of different ages, or on cross-sectional studies that included subsamples of children distributed in distinct age groups (e.g., Acebo et al., 2005; Crosby et al., 2005; Ward et al., 2008). In both cases, child age is inherently confounded with other subsample characteristics or study parameters, limiting the possibility to draw reliable conclusions about developmental increases and decreases. In contrast, longitudinal studies with at least three assessment time points on the same children allow for the study of true patterns of developmental change (Bornstein, Putnick, & Esposito, 2017; Fraley, Roisman, & Haltigan, 2013). Such designs are essential to answer key developmental questions, such as those pertaining to the shape of developmental trajectories, timing and chronicity of sleep problems, and how improvements or deteriorations in sleep predict changes in other domains of functioning (El-Sheikh & Kelly, 2017). Yet, few studies have used longitudinal designs along with objective actigraphic measures to document stability and change in preschoolers' sleep. Scher, Epstein, and Tirosh (2004) assessed children's sleep from 20 to 42 months of age and found rank-order stability in nighttime sleep quality, but not in nighttime sleep duration. With children around 41 months of age, Anders, Iosif, Schwichtenberg, Tang, and Goodlin-Jones (2011) found that 24-hour sleep duration decreased and nighttime sleep quality increased over a six-month period. Finally, Staples, Bates, and Petersen (2015) found that 24-hour sleep duration decreased significantly between 30 and 42 months, which was explained by reduced daytime sleep duration.

Of note, these three studies used mean-level differences or continuity in rank order to characterize stability and change in preschoolers' sleep. While important, these approaches do not offer information about intra-individual development (i.e., within-person changes across time; Bornstein et al., 2017). In contrast, growth modeling approaches lend themselves to examining intra-individual patterns of development and comparing individuals on these patterns (inter-individual differences in intra-individual rates of change). Longitudinal designs supplemented by such statistical approaches allow for the identification of developmental patterns in children's sleep (often called sleep growth curves), an aspect of development that is mostly unknown thus far (El-Sheikh & Kelly, 2017), particularly in the preschool period.

With school-age children and adolescents, a limited literature has examined sleep growth curves, mostly in relation to youths' adjustment (e.g., depression, internalizing and externalizing problems, cognition; Bub, Buckhalt, & El-Sheikh, 2011; El-Sheikh, Bub, Kelly, & Buckhalt, 2013; Fredriksen, Rhodes, Reddy, & Way, 2004; Goodnight, Bates, Staples, Pettit, & Dodge, 2007). Together, these studies suggest that the developmental trends in sleep indices bear meaningfully on child adjustment.

Given that sleep seems to undergo even more significant developmental changes in the preschool years, documenting the developmental patterns in sleep before age 5 is a critical step toward understanding their implications for young children's adjustment.

To our knowledge, few studies have used contemporaneous statistical techniques of longitudinal analysis to do so. Touchette et al. (2008, 2009) addressed nighttime sleep duration between 2 and 6 years, Magee, Gordon, and Caputi (2014) examined daily sleep duration between 0 and 7 years, and Weinraub et al. (2012) as well as Hsu (2017) focused on nocturnal awakening between 6 and 36 months. Recently, Kocevska et al. (2017) examined sleep disturbances between 2 months and 6 years. Thus, each of these studies focused on one sleep variable only. Furthermore, five of these six studies used a group-based approach (growth mixture modeling or latent class trajectory modeling) to identify groups of children following distinct developmental patterns. A growth curve approach (Hsu, 2017) provides complementary information, describing how each sleep variable develops on average and how each child varies around the average. Most importantly, all six aforementioned studies used parental reports to measure children's sleep, which can lead to different biases inherent to the parent, the level of adhesion, and the burden that filling the questionnaire may represent (Sadeh, 2015).

Overall, current knowledge on developmental patterns of change in sleep during the preschool period is limited for several reasons. To begin with, the majority of studies are cross-sectional and the statistical approaches used generally do not estimate intra-individual changes in sleep and inter-individual differences in these changes. Moreover, in many studies, sleep is measured using parental reports. Finally, most studies focus on one or two sleep indices, indicative of either duration or quality of sleep, although Dewald, Meijer, Oort, Kerkhof, and Bögels (2010) observed that duration and quality represent distinct domains of sleep that are differently associated with developmental outcomes, and therefore should be studied separately. In most studies using actigraphy, sleep duration represents the quantity of sleep (i.e., actual time spent asleep), whether during the day, the night, or over the whole 24-hour period. Sleep quality usually refers to indices such as the number or duration of night awakenings, as well as sleep efficiency (proportion of the sleep period spent asleep). There is some evidence for compensatory mechanisms between sleep duration and quality. Ward et al. (2008) observed that night awakenings were more frequent among children who napped compared to non-nappers and hypothesized that children with lower-quality sleep needed a nap during the day to meet their total sleep needs. In addition to duration and quality, sleep can also be characterized by its distribution over the 24-hour day period (Sadeh, 2015). Accordingly, in the current study, variables characterizing sleep duration, quality, and distribution were assessed.

The current study

The current three-wave (2, 3, and 4 years of age) longitudinal study investigated the developmental patterns of change in five actigraphic sleep variables during the preschool period. As proposed by Bornstein et al. (2017), these developmental changes were examined using complementary approaches. First, traditional analytic methods were used, including examination of group averages at each age and change in the relative order of individuals through time (indexed by correlations). Next, a multilevel modeling (MLM) framework was used to examine intra-individual change (from age to age) and whether there were significant inter-individual differences in rates of change. To our knowledge, this study is the first to characterize developmental patterns of change in actigraphy-derived preschool sleep variables formally, in addition to quantifying intra-individual change across time and inter-individual differences in these patterns of change. Considering the results of previous studies, we predicted stability in nighttime sleep duration, a linear decrease of daytime and total daily sleep duration, and a linear increase in the proportion of nighttime sleep and sleep efficiency across the preschool years.

Method

Participants

This study is part of a larger longitudinal project on early parent-child relationships and children's developmental pathways (Bernier, Beauchamp et al., 2020). The current sample consisted of 128 children (67 boys and 61 girls) for whom sleep trajectories were estimated. Families lived in a large Canadian metropolitan area and were recruited using random birth lists provided by the Ministry of Health and Social Services. Criteria for participation (upon recruitment when children were 7-8 months old) were a full-term pregnancy (i.e., at least 37 weeks of gestation) and the absence of any physical or mental abnormality in the child. Written informed consent was obtained from mothers prior to the beginning of the study and the study protocol was approved by the university's institutional review board. Upon recruitment, mothers were between 20 and 45 years (M = 31.73, SD = 4.5), had an average of 16 years of education (SD = 2.2) and were mostly Caucasian (91.4%). Fathers were between 21 and 58 years (M = 34.09, SD = 5.8), had an average of 16 years of education (SD = 2.4) and were generally Caucasian (81.3%). Annual family income (in Canadian dollars) varied from less than $20,000 to over $100,000, with a mean situated in the $60,000 –$79,000 bracket. Finally, 37% of children were first born and 63% had older siblings.

Procedure

Children's sleep was assessed on three consecutive days at 2 (22 to 28 months; M = 25.1 months), 3 (35 to 41 months; M = 36.8 months) and 4 years of age (47 to 51; M = 48.8 months). The three-night period was chosen with the aim of reducing child and family burden and thus optimizing compliance. Although Acebo et al. (1999) recommended the use of at least five nights of actigraphy recordings to obtain optimally reliable measures, one notes from closer inspection of their data that satisfactory levels of reliability (close or superior to .70) can be obtained with three days of assessment. Families took part in home visits at the end of which a research assistant left an actigraph and a sleep diary with the mother and provided her instructions for each one. Parents were asked to choose three days during which their child had a fairly usual routine for the sleep assessment. Overall across children, most nights of assessment (70% at 2 years, 71% at 3 years, and 67% at 4 years) took place on weekdays. Estimates of sleep variables were unrelated to the type of day (weekday vs. weekend; all *p*s > .25). A financial compensation of $20 was offered to families when the child wore the actigraph in accordance with instructions and the mother filled out the sleep diary.

Among the 128 children, 85 had analyzable sleep data at 2 years, 63 at 3 years, and 65 at 4 years. Missing data were attributable to the fact that families missed the first assessment (did not have time or could not be contacted at 2 years; n = 12), left the study afterward (moved away or no longer had time; 33 at 3 years, and 29 at 4 years), children refused to wear the actigraph (n = 12 at 2 years, 22 at 3 years, and 18 at 4 years), the mother did not complete the sleep diary (used to double-check the actigraphy data; see below) on any of the three days (n = 13 at 2 years, 3 at 3 years, and 11 at 4 years), or all data had to be discarded due to the identification of potential artefacts in the actogram (n = 6 at 2 years, 7 at 3 years, and 5 at 4 years). The number (one, two or three) of sleep assessment time points was not significantly associated with sleep estimates or sociodemographic variables (maternal and paternal ethnicity, education, and age, family income, child sex, or number of siblings; all *p*s > .06). In all, 128 children had usable data on at least one of the sleep assessment points; in keeping with best practices to handle missing data in longitudinal designs (Enders, 2010), these 128 children formed the analytic sample.

Measures

Actigraphy. At 2, 3 and 4 years, children wore an actigraph (Mini-Mitter® Actiwatch, Respironics; AW-64), a small watch-like computerized monitor that continuously records body movements through an accelerometer. Children wore the actigraph around the ankle or wrist for 72 consecutive hours, except when they were in contact with water, for example when bathing or swimming. Activity level was recorded in 30-second epochs and data were downloaded to a computer and analyzed to convert the motor activity data into estimates of sleep and wake periods. As actigraphy tends to overestimate night awakenings because of young children's higher level of motor activity during sleep (Meltzer, Montgomery-Downs, Insana, & Walsh, 2012), data were analyzed initially with the manufacturer's low sensitivity threshold algorithm (80 activity counts per epoch). This algorithm has been found to be the most appropriate for preschoolers (Bélanger, Bernier, Paquet, Simard, & Carrier, 2013). However, even this more appropriate algorithm (relative to those involving 20 or 40-activity count thresholds) overestimates awakenings (Bélanger et al., 2013). Thus, a secondary "smoothing" algorithm, developed specifically to address the problem of overestimation of night waking, was then applied to the nighttime data derived from the 80-activity count threshold. This smoothing method requires a minimum 2-min awakening period following sleep onset to score an awakening (Sitnick, Goodlin-Jones, & Anders, 2008). This algorithm has been validated against videosomnography (Sitnick et al., 2008) and home-based polysomnography (Bélanger et al., 2013).

All actigraphic data were scored by a research assistant who was experienced with actigraphy data scoring. To score nighttime sleep, the research assistant examined the actogram (graphical representation of activity level provided by the actigraphy software) and manually defined sleep onset (the start of the first consecutive minutes of sleep; i.e., consecutive minutes for which the activity count was at or near zero) and sleep offset (the end of the last minutes of sleep). To guide examination of the actogram, the assistant used sleep onset and offset times indicated on the diary. To identify naps, the assistant identified periods during the day (i.e., between wake up in the morning and 5 pm) where the activity count was at or near zero and looked for maternal confirmation of a nap at that time on the diary. Mothers were also asked to note on the diary all moments where their child was not wearing the actigraph, which allowed the research assistant to make sure that moments without motor activity were attributable to sleep, and not to the child having removed the actigraph.

Sleep variables derived from actigraphy were: (a) nighttime sleep duration (number of minutes scored as sleep between nighttime sleep onset and offset); (b) daytime sleep duration; (c) total sleep duration over a 24-hour period (the sum of nighttime and daytime sleep duration); (d) proportion of nighttime sleep (percentage of total daily sleep occurring at night – an index of sleep distribution) and (e) sleep efficiency (number of minutes scored as sleep between nighttime sleep onset and offset/ [number of minutes scored as sleep + number of minutes scored as wake between sleep onset and offset] x 100). For each sleep variable, the average over the three days of assessment was used.

Actigraphy constitutes an objective and minimally invasive way to collect sleep data in the natural environment, and several studies have demonstrated its validity for sleep assessment in children (Acebo et al., 1999; Sadeh, Lavie, Scher, Tirosh, & Epstein, 1991; Sung, Adamson & Horne, 2009). The actigraph model used in this study demonstrates good to high correspondence (77-98%, depending on the sleep variable studied) with polysomnography for this age group, regardless of location (ankle or wrist; Bélanger et al., 2013).

Sleep diary. During the same 72 hours that the child was wearing the actigraph, the mother was asked to fill out a sleep diary, used to confirm the validity of actigraphic data. To minimize memory biases, the mother was asked to complete the sleep diary in real time (i.e., as the day unfolded rather than retrospectively at the end of the three-day period). The mother had to note, on a 24-hour timeline divided into 30-minute periods, whether the child was awake or asleep for each period. She also indicated where the child was sleeping and whether particular events (such as illness, medication taking, or visitors at home) could have disrupted her child's sleep. The specific days where sleep data might be unrepresentative of the child's usual sleep patterns were discarded. Specific days when examination of the sleep diary suggested that the actogram was invalid (e.g., recording of movement induced by an external object, such as while the child slept in a stroller or car; child removing the actigraph), or when actigraphy data showed low correspondence with the sleep diary were also rejected to ensure optimally reliable data. At each age, the majority of children had 3 days of valid data. At 2 years, 68 children had 3 days, 10 had 2 days, and 7 had 1 day. At 3 years, 44 children had valid data on 3 days, 15 on 2 days, and 4 for 1 day. Finally, at 4 years, 53 had 3 days of valid data, 7 had 2 days, and 5 had 1 day. Overall, only 4 children (i.e., approx. 3% of the sample) had valid data for one day at every time point. When removing these 4 children from analyses, the results were the same; therefore, they were retained in the analytic sample.

In order to be scored as sleep, a daytime sleep period had to be both indicated by the mother on the diary as a nap and identified as sleep in the actigraphy data. At each age, the majority of children attended daycare (81.7% at 2 years, 87.3% at 3 years, and 92.9% at 4 years). In these cases, the mother asked the child care educator about nap periods at the end of each day and reported them on the diary.

Analytic Strategy

To eliminate the need to delete individuals with missing data, and consequently increase statistical power, full information maximum likelihood (FIML) estimation was used. Numerous studies have shown the superiority of FIML in comparison with classical methods of handling missing data (e.g., listwise and pairwise deletion; Enders & Bandalos, 2001; see Enders, 2010). Contrary to other methods, FIML produces unbiased and stable estimates under a missing at random data mechanism, such as that observed here (Enders, 2010).

With the aim of describing patterns of change in children's sleep during the preschool period, growth curves were fitted in Mplus 7.4 using a multilevel modeling (MLM) framework, also known as Hierarchical Linear Modeling (HLM). MLM was chosen here because it can easily handle the difficulties generated by specific conditions such as small samples (groups as small as 30–50 are sufficient for reliable modeling), partially missing data, and unequally spaced time points (Burchinal, Nelson, & Poe, 2006; Singer & Willett, 2003), which were encountered in the current study. MLM treats repeated observations as nested within individuals and models change on two levels: level 1 that represents individual (within-person) change over time and level 2 representing the extent to which change differs across individuals (between-persons; Singer & Willett, 2003).

The first step is to specify an intercept-only model (null model) that does not include any explanatory variables (i.e., any level-1 or level-2 predictors) and postulates that there is no change over time. This model is particularly useful for calculating the intraclass correlation coefficient (ICC) and thus allows decomposing the total variance of the studied phenomenon into inter-individual and intra-individual variance (Geiser, 2012; Luke 2004). Next, in order to identify the best-fitting model of change in children's sleep, two unconditional models were specified for each sleep variable : 1) Model A (i.e., fixed linear model), which included the fixed effect of child exact age in years and months as level-1 predictor, coded such that the intercept represented the average for the sleep variable at the first assessment and the slope represented the average yearly decrease or increase in this variable, and 2) Model B (i.e., random linear model), which included the random effect of time, that is, between-person variability in individual slopes. Using child exact age at each assessment point enabled us to flexibly handle individually varying assessment times and to estimate change in child sleep across a broad range of ages (from 1.83 to 4.25 years). Finding Model A to be the best-fitting model for a given variable would indicate that the developmental trajectory for this sleep variable is best represented by a linear pattern of change that is relatively uniform (i.e., negligible differences) across children, whereas Model B as best-fitting would rather suggest that there is variation between children in rate of change. Finally, a fixed quadratic term was added (Model C) to explore whether there was a significant acceleration or deceleration in rate of change across time (i.e., indicating a decreasing or increasing curvilinear trajectory). Different indicators were used to determine which growth model presented the best fit to the data: the random effects and quadratic terms were retained if the pertinent p-value for the estimates were $< .05$ or if the model's log likelihood (-LL) differed significantly with the addition of the random or quadratic slope terms, based on a chi-square difference test. The best-fitting models are presented in Table 3.

Results

Preliminary analyses: Traditional analytic methods

Table 1 presents the means, ranges, correlations across time points, and inter-correlations among sleep variables. Examination of average scores suggests that nighttime, daytime, and total daily sleep durations tend to decrease overall during the preschool period, whereas sleep efficiency and proportion of nighttime sleep seem to increase slightly. The low to moderate coefficients of stability (correlations across age) for sleep variables indicate changes in inter-individual differences across time. These changes suggest the presence of between-children differences in patterns of growth in sleep across time, which will be formally examined next with multilevel growth modeling. At each time point, nighttime sleep duration was positively and significantly associated with total daily duration, proportion of nighttime sleep, and sleep efficiency. It was also negatively associated with daytime sleep duration, and this correlation increased in magnitude and statistical significance from age to age. Total daily sleep duration was negatively associated with proportion of nighttime sleep and positively associated with sleep efficiency. Daytime sleep duration was strongly negatively associated with proportion of nighttime sleep as expected, but unrelated to sleep efficiency. Finally, sleep efficiency and proportion of nighttime sleep were unrelated to each other.

Main analyses: Describing children's sleep growth curves

In addition to the models discussed below, a fixed quadratic model was tested for all sleep variables, but no significant change in slope (i.e., quadratic effect) was obtained, and this model (Model C) was not the best fitting for any of the sleep variables. Accordingly, quadratic models are not discussed further. Correlations between initial status and rate of change were also examined for all variables, and none was significant. Figures 1 and 2 illustrate each sleep variable's growth curve, described next.

Nighttime sleep duration. The intercept-only model (see Table 2) revealed that 22% of the variance in nighttime sleep duration was inter-individual (vs. 78% intra-individual), as shown by the intra-class correlation (ICC; .22). With regard to unconditional growth models, the best-fitting model was a fixed linear model (Model A; Table 3), indicating a constant albeit non-significant decrease across time. This decrease, however, is non-negligible, given that Model A provided better fit to the data than the intercept-only model, which postulates that there is no change over time. When the effect of age was removed, the fit of the model decreased (LL = -252.89), further suggesting that it is important to retain age in the model even though the rate of change is not statistically significant. Model A showed that nighttime sleep duration started at 9.45 hours (γ00) and decreased by 5.4 minutes (γ10) per year. The small magnitude of the slope (γ10) shows a slow decrease across time. There was significant inter-individual variability around the initial status (σ_0^2 = .16). When the random effect of time (i.e., between-person variability in individual slopes) was added (Model B), there was no inter-individual variability around the rate of change ($\sigma_1^2 = .09$) and the fit of the model decreased, which indicates that the decrease in nighttime sleep duration was relatively uniform across children. In sum, nighttime sleep duration was characterized by a slight, non-significant decrease that did not vary significantly from one child to another.

Daytime sleep duration. The ICC (.19) of the intercept-only model (see Table 2) indicated that the variance was mostly intra-individual (81%). The best-fitting model was a fixed linear model (Model A; Table 3), indicating a significant and consistent decrease in daytime sleep across time. Model A showed that, on average, daytime sleep started at 2.22 hours (γ00) at the beginning of the preschool period and decreased by 18 minutes per year (γ10). There was significant between-person variability around the initial status (σ_0^2 = .22). When the random effect of time was added (Model B), the fit of the model was reduced (LL = -217.94) and there was no significant between-person variability around the rate of change (σ_1^2 = .11). Therefore, daytime sleep duration was characterized by a significant decrease that did not vary significantly across children.

Total daily sleep duration. According to the intercept-only model (see Table 2), only 10% of the total variance was inter-individual (ICC = .10). The best fitting model for total daily sleep duration was a random linear model (Model B; Table 3), indicating a significant and consistent decrease in children's total sleep across time. This model indicated that on average, total daily sleep duration decreased by 22 minutes (γ10) per year, starting at 11.63 hours (γ00) at the beginning of the preschool period. There was significant between-person variability around the initial status (σ_0^2 = .97), but not around the rate of change (σ_1^2 = .17). Although the variability around the slope was not significant, removing the slope variance decreased the fit of the model (LL = -253.03), which indicates that Model B is the model that best describes change in total daily sleep duration across the preschool years. This change was characterized by a significant decrease that did not vary significantly from one child to another, although that variation was non-negligible.

Proportion of nighttime sleep. The intercept-only model (see Table 2) suggested that about half of the variance in the proportion of nighttime sleep was inter-individual (ICC = .52). The model with the best fit was a fixed linear model (Model A; Table 3). The proportion of nighttime sleep thus followed a linear trajectory characterized by a significant and constant increase across the preschool years. According to this fixed linear model, the proportion of nighttime sleep started on average at 81.18% (γ00) and increased by 2.23% (γ10) per year. There was marginal variability around the initial status (σ_0^2 = 13.53). When the random effect of time was added (Model B), the fit of the model was reduced (LL = -568.15) and there was no significant between-person variability around the rate of change (σ_1^2 = 12.57), which confirmed that Model A better represented the trajectory of this variable. In sum, there was a significant increase in the proportion of nighttime sleep that did not vary significantly between children.

Sleep efficiency. The intercept-only model (see Table 2) indicated almost exclusively intra-individual variance in sleep efficiency (ICC = .05). The best fitting model for sleep efficiency was a random linear model (Model B; Table 3), characterized by a significant and constant increase over time. On average, sleep efficiency increased by 2.14% (γ10) per year, starting at 90.55% (γ00) at age 2. There was significant between-person variability around the initial status (σ_0^2 = 21.40), but not around the rate of change (σ_1^2 = 3.87). Although there was no significant variability around the slope, removing this parameter decreased the fit of the model (LL = -652.83), so Model B remained the model that best described change in sleep efficiency, namely a significant increase that did not vary significantly from one child to another, although that variation was non-negligible.

Discussion

The aim of this study was to formally characterize the developmental changes in sleep that take place across the preschool years using actigraphy-derived indicators of sleep analyzed with state-of-the-art statistical techniques. Multilevel modeling was used to examine intra-individual change (from age to age) in each sleep variable and whether there were significant inter-individual differences in rates of change. The results suggested that significant changes in children's sleep occur between 2 and 4 years (specifically, between 1.83 and 4.25 years) and that different sleep variables show distinct (albeit all linear) patterns of growth across time. Findings also indicated relatively similar shape and rhythm of change across children on all sleep variables, although some variables showed significant variability between children around the initial status at 2 years. In addition, there was some indication of non-negligible (albeit non-significant) between-children variability in the slope of two of the considered parameters. Importantly, the results also suggested that rank-order relative stability could occur alongside significant intra-individual increases or decreases, and vice-versa, highlighting the importance of disentangling intra- and inter-individual aspects of developmental changes in sleep.

Sleep during the preschool period: Traditional analytic methods

Before considering the findings of the growth curves analyses, it may be useful to consider first the results that emanated from the more traditional approaches as used in previous studies. Age-specific average levels of sleep duration (daytime, nighttime, and total) appeared to decrease slightly between 2 and 3 years of age, and more markedly between 3 and 4 years of age, while sleep efficiency and proportion of nighttime sleep seemed to increase, although sometimes very modestly. These observed trends were broadly consistent with the findings of previous studies (e.g., Acebo et al., 2005; Iglowstein et al., 2003; Magee et al., 2014; Ward et al., 2008), and tested more formally next with multilevel modeling.

At each age, nighttime sleep duration was negatively associated with daytime sleep duration, and this correlation increased in magnitude and statistical significance from age to age, becoming reliable at age 4. This negative correlation is consistent with previous actigraphic studies (Acebo et al., 2005; Ward et al., 2008; see El-Sheikh, Arsiwalla, Staton, Dyer, & Vaughn, 2013 for an exception) and might suggest that napping leads to a lesser need for sleep at night, or conversely, that shorter nighttime sleep results in a greater need to nap during the day so as to meet total sleep requirements (Thorpe et al., 2015; Ward et al., 2008). However, such compensation mechanisms do not appear to be at play at age 2, which might indicate that naps are more necessary in the early preschool period and slowly become mostly compensatory for lack of nighttime sleep as children approach age 4.

Findings also revealed generally low to moderate stability (i.e., low to moderate correlation coefficients between assessment times) for sleep variables, suggesting changes across time in inter-individual differences (i.e., children do not tend to maintain their position relative to other children, potentially because their sleep does not change at the same pace as other children). These analyses thus suggested that sleep is characterized by an instability in children's rank-order across the preschool years. To examine this further and increase our understanding of the normative development of sleep during this period, it is necessary to examine intra-individual patterns of change in distinct sleep variables, which requires growth curve modeling (Bornstein et al., 2017).

Patterns of growth in children's sleep during the preschool period

Multilevel growth modeling showed that all sleep variables followed a linear trajectory, indicating a constant rate of change across the preschool period. Hence, the apparent increases or decreases suggested above were confirmed and shown to be relatively constant across time, as no significant acceleration or deceleration in change was observed. All sleep variables inherent to sleep duration (nighttime, daytime and daily duration) followed a linear decrease, whereas the proportion of nighttime sleep and sleep efficiency followed a linear increase. For all sleep variables, Model A (postulating change over time) proved to be a better fit to the data than the intercept-only model (postulating a flat trajectory), which indicates the presence of a non-negligible effect of time on all sleep indices assessed in this study. It is important to note that the decrease was not statistically significant in the case of nighttime sleep duration. However, although the slope estimate was not significantly distinguishable from 0, it may have been with a larger sample size, given that the intercept-only model, postulating no effect of time, was a worse fit to the data than the fixed linear model, which includes change over time. Thus, we tentatively suggest that nighttime sleep duration likely exhibits a slow (vs. no) decrease across the preschool years.

In sum, the significant slopes observed on four on the five studied sleep variables suggest that sleep undergoes significant linear developments at the intra-child level (individual changes from age to age) across the preschool period. It is interesting to note that in the growth analyses, these increases or decreases were estimated as relatively constant (i.e., no significant acceleration or deceleration in change), whereas initial examination of average scores suggested that the decrease of daytime, nighttime, and total sleep duration appeared more pronounced between 3 and 4 years of age than between 2 and 3 years. When lumping children's sleep values into group averages at each age, their values appear to change more rapidly between 3 and 4 years than between 2 and 3 years, which speaks to average group-level tendencies. In contrast, growth curve analyses first model one slope across time per child, and then average out these slopes. Hence, growth modeling analyses focus first on the changes that occur over time for each child, allowing to capture within-child developmental tendencies, and suggest in this case that the average child's sleep does not change more rapidly between 3 and 4 than between 2 and 3 years. Such results highlight the importance of examining different types of change and stability (i.e., distinguishing between group tendencies and intra-individual patterns) in order to obtain a more complete picture of a longitudinal process (Bornstein et al., 2017). To our knowledge, this study is the first to do so with several sleep variables objectively assessed among preschoolers.

In addition to the examination of intra-individual changes across time and individual differences therein, another uniquely informative aspect of growth modeling is the possibility to partition the observed variance in two sources, intra-individual and inter-individual. These analyses revealed that large proportions of the variance (78%-93%) in four of the five sleep variables (with the exception of proportion of nighttime sleep; 48%) were intra-child, and thus could be attributed to within-individual factors, namely increasing age and associated intrinsic maturational processes. Indeed, it appears sensible that maturation could play a substantial role in the changes found in this study, which together represent increasingly more mature sleep patterns. The development of sleep-wake cycles is driven partly by the maturation of two intrinsic bio-regulatory processes: a homeostatic process, whereby sleep pressure accumulates with time awake and dissipates during a sleep episode, and a circadian process, which is independent of prior waking and provides cyclical signals promoting alertness versus sleep (Jenni & LeBourgeois, 2006; see also Borbély, 1982). It has been observed that the homeostatic process slows down at preschool age, resulting in the need for sleep to accumulate less rapidly during wake episodes as children get older. This deceleration in the homeostatic process is believed to contribute to the gradual decrease in children's sleep duration, particularly daytime sleep (Jenni & LeBourgeois, 2006). The circadian process also undergoes development during the preschool period, with circadian sleep regulation (i.e., the proportion of variance in sleep and wake that is explained by the circadian process) becoming increasingly more important (Dearing, McCartney, Marshall, & Warner, 2001). Maturation of the circadian process facilitates adaptation to the 24-hour light and dark cycles, which is likely to promote sleep consolidation and efficiency. Thus, overall, normative maturation of homeostatic and circadian processes may partly explain the developmental changes observed here in sleep variables, namely shorter total and daytime duration as well as better consolidation (proportion of nighttime sleep) and efficiency.

Another set of findings that emanated from this study pertained to individual differences in the developmental trends just described. The rate of change appeared relatively similar for all subjects, as variance around the slope was statistically non-significant for all sleep variables. This suggests that changes in preschoolers' sleep occur at a rhythm that is relatively uniform across children (at least those not drawn from clinical populations). It is possible that this similarity in the rate of change is due to the influence, described above, of maturational factors (e.g., maturation of homeostatic and circadian processes) that generally affect same-age children in relatively similar ways – this also contributes to explaining the large proportion of intra-individual variance observed on most sleep variables. However, all sleep variables presented significant or marginal (in the case of proportion of nighttime sleep) inter-individual variation around the initial status (i.e., age-2 level). This suggests that although their sleep patterns develop at relatively similar rates, not all children enter the preschool period at the same level in sleep indices. These early individual differences in the initial status are likely due to both biological and environmental factors.

One last finding that could not have been obtained with conventional statistical analyses is the independence of the intercept and rate of change on all variables considered. This indicates that initial status does not predict preschoolers' patterns of change in sleep; hence, children who slept less or less well than their peers at 2 years did not catch up with them over the 2.5-year period covered by this study (22 to 51 months). The persistence of these differences suggests that early sleep patterns may set children on a trajectory that could have significant long-term consequences. These results also indicate that initial status and rate of change are two distinct ways to characterize preschoolers' sleep, which could predict different outcomes.

Limitations

This study presented some limitations that need to be noted. The use of a low-risk community sample limits the generalizability of the results, most notably to clinical samples that may, in fact, be characterized partly by failure to follow the normative trends described here. Also, the relatively low diversity of the sample may have influenced the findings; in particular, one may speculate that the small proportion of inter-individual variation found in most sleep variables is due in part to the relatively homogeneous sample. Further studies with children from more varied backgrounds would be useful in determining whether there is greater inter-individual variation in more diverse samples (e.g., in terms of family socioeconomic status, ethnicity, and others). For instance, there is some evidence that family income relates to sleep trajectories in the preschool period (e.g., Magee et al., 2014), thus suggesting that there may be more inter-individual variation in more diverse samples. As is often the case in studies that use objective sleep measures with young children (e.g., Berger, Miller, Seifer, Cares, & LeBourgeois, 2012; Scher, Hall, Zaidman-Zait, & Weinberg, 2010; Vaughn et al., 2011), the sample was relatively small, which, however, was handled using an MLM approach, chosen based on its demonstrated capacity to yield unbiased and accurate estimates with small samples. It has been suggested that groups as small as 30–50 are sufficient for reliable modeling

(Burchinal et al., 2006) and simulation studies have shown that only sample sizes of 50 or less can result in biased estimates in MLM (Maas & Hox, 2005). Also, many participants had missing sleep data at some assessment waves, especially at 3 and 4 years, as attrition is an inevitable characteristic of longitudinal research. Consequently, suitable methods were used to handle missing data and minimize bias associated with attrition (Enders, 2010): group equivalence was examined, and an appropriate method to handle missing data (FIML) was used, which yields stable and robust estimates under the pattern of missing data observed here. Moreover, actigraphy data were available for a maximum of three nights. Although this is not unusual when working with young children (e.g., Scher et al., 2010; So, Buckley, Adamson, & Horne, 2005; Ward et al., 2008), it is preferable to use at least five days (Acebo et al., 1999). Also, most children attended daycare and daycare facility policies with regard to napping (e.g., if napping was required, facilitated, or discouraged), which we did not assess, may have influenced napping opportunity and consequently daytime and total sleep duration. Finally, both weekdays and weekends were included in the sleep assessment, which could constitute a confounding factor. However, the type of day (week or weekend) was unrelated to any sleep variable, consistent with studies suggesting that among young children and in contrast to older children or adolescents, sleep patterns do not vary between weekends and weekdays, including on the variables examined here (e.g., Goodlin-Jones, Tang, Liu, & Anders, 2008; Hatzinger et al., 2012; Price et al., 2013).

Conclusion

The current study relied on a longitudinal design, an advanced statistical approach, and an objective measure of sleep and is the first (to our knowledge) to describe the developmental trajectories followed by several actigraphy-derived sleep variables during the preschool period and to examine individual differences in these developmental trends. The data presented can constitute building blocks toward the establishment of norms regarding normative sleep developments during the preschool period. As other studies appear and such norms become increasingly established, parents and health professionals who work with preschoolers will be able to determine whether a child's sleep seems to follow a normative pattern of development or if, on the contrary, the child markedly fails to follow these trends and may thus need clinical attention. However, given that this is the first study to describe growth curves of objectively assessed sleep in the preschool years, other studies are necessary to corroborate the results presented here (notably in more diverse samples) before developmental norms become consensual. Future research should also aim to test the role of biological and environmental factors in the prediction of inter-individual differences in both initial status and rate of change of different sleep variables at preschool age. Given that developmental trajectories of sleep at school age and in adolescence are meaningfully associated with child functioning in several areas (Bub et al., 2011; El-Sheikh et al., 2013; Fredriksen et al., 2004; Goodnight et al., 2007), research should strive to identify domains of functioning that are impacted by preschoolers' sleep trajectories as well.

References

Acebo, C., Sadeh, A., Seifer, R., Tzischinsky, O., Hafer, A., & Carskadon, M. (2005). Sleep/wake patterns derived from activity monitoring and maternal report for healthy 1- to 5- year-old children. *Sleep, 28,* 1568-1577. doi:10.1093/sleep/28.12.1568

Acebo, C., Sadeh, A., Seifer, R., Tzischinsky, O., Wolfson, A. R., Hafer, A., & Carskadon, M. A. (1999). Estimating sleep patterns with activity monitoring in children and adolescents: How many nights are necessary for reliable measures? *Sleep, 22,* 95-103. doi:10.1093/sleep/22.1.95

Anders, T. F., Iosif, A. M., Schwichtenberg, A. J., Tang, K., & Goodlin-Jones, B. L. (2011). Six-month sleep–wake organization and stability in preschool-age children with autism, developmental delay, and typical development. *Behavioral Sleep Medicine, 9*, 92-106. doi:10 .1080/15402002.2011.557991

Bélanger, M. È., Bernier, A., Paquet, J., Simard, V., & Carrier, J. (2013). Validating actigraphy as a measure of sleep for preschool children. *Journal of Clinical Sleep Medicine, 9*, 701-706. doi:10.5664/jcsm.2844

Bélanger, M. È., Bernier, A., Simard, V., Desrosiers, K., & Carrier, J. (2018). Sleeping toward behavioral regulation: Relations between sleep and externalizing symptoms in toddlers and preschoolers. *Journal of Clinical Child & Adolescent Psychology*, *47*, 366-373. doi:10.1080 /15374416.2015.1079782

Berger, R. H., Miller, A. L., Seifer, R., Cares, S. R., & LeBourgeois, M. K. (2012). Acute sleep restriction effects on emotion responses in 30-to 36-month-old children. *Journal of Sleep Research, 21*, 235-246. doi:10.1111/j.1365-2869.2011.00962.x

Bernier, A., Beauchamp, M. H., Bouvette-Turcot, A. A., Carlson, S. M., & Carrier, J. (2013). Sleep and cognition in preschool years: Specific links to executive functioning. *Child Development, 84*, 1542-1553. doi:10.1111/cdev.12063

Borbély, A. A. (1982). A two process model of sleep regulation. *Human Neurobiology, 1*, 195-204. Retrieved from: https://s3.amazonaws.com/academia.edu.documents/32314612/Borbely_AA_%281982%29_Human_Neurobiology_1__195204.pdf

Bornstein, M. H., Putnick, D. L., & Esposito, G. (2017). Continuity and stability in development. *Child Development Perspectives*, *11*, 113-119. doi:10.1111/cdep.12221

Bub, K. L., Buckhalt, J. A., & El-Sheikh, M. (2011). Children's sleep and cognitive performance: A cross-domain analysis of change over time. *Developmental Psychology, 47*, 1504-1514. doi:10.1037/a0025535

Burchinal, M. R., Nelson, L., & Poe, M. (2006). IV. Growth curve analysis: An introduction to various methods for analyzing longitudinal data. *Monographs of the Society for Research in Child Development, 71*, 65-87. doi:10.1111/j.1540-5834.2006.00405.x

Crosby, B., LeBourgeois, M. K., & Harsh, J. (2005). Racial differences in reported napping and nocturnal sleep in 2-to 8-year-old children. *Pediatrics, 115*, 225-232. doi:10.1542/peds.2004-0815D.

Dahl, R. E. (1996). The regulation of sleep and arousal: Development and psychopathology. *Development and Psychopathology, 8,* 3-27. doi:10.1017/S095457940000694

Dahl, R. E. (1998). The development and disorders of sleep. *Advances in Pediatrics, 45*, 73-90. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/9742298

Davis, K. F., Parker, K. P., & Montgomery, G. L. (2004). Sleep in infants and young children. Part one: Normal sleep. *Journal of Pediatric Health Care, 18*, 65-71. doi:10.1016/S0891-5245(03)00149-4

Dearing, E., McCartney, K., Marshall, N. L., & Warner, R. M. (2001). Parental reports of children's sleep and wakefulness: Longitudinal associations with cognitive and language outcomes. *Infant Behavior and Development, 24,* 151-170. doi:10.1016/S0163-6383 (01)00074-1

De Koninck, J., Lorrain, D., & Gagnon, P. (1992). Sleep positions and position shifts in five age groups: An ontogenetic picture. *Sleep*, *15*, 143-149. doi:10.1093/sleep/15.2.143

Dewald, J. F., Meijer, A. M., Oort, F. J., Kerkhof, G. A., & Bögels, S. M. (2010). The influence of sleep quality, sleep duration and sleepiness on school performance in children and adolescents: A meta-analytic review. *Sleep Medicine Reviews*, *14*, 179-189. doi:10.1016 /j.smrv.2009.10.004

El-Sheikh, M., Arsiwalla, D. D., Staton, L., Dyer, W. J., & Vaughn, B. E. (2013). Associations between preschoolers' daytime and nighttime sleep parameters. *Behavioral sleep medicine, 11*, 91-104. doi:10.1080/15402002.2011.625460

El-Sheikh, M., Bagley, E. J., Keiley, M., Elmore-Staton, L., Chen, E., & Buckhalt, J. A. (2013). Economic adversity and children's sleep problems: Multiple indicators and moderation of effects. *Health Psychology*, *32*, 849-859. doi:10.1037/a0030413

El-Sheikh, M., Bub, K. L., Kelly, R. J., & Buckhalt, J. A. (2013). Children's sleep and adjustment: A residualized change analysis. *Developmental Psychology, 49*, 1591-1601. doi:10.1037/a0030223

El-Sheikh, M., & Kelly, R. J. (2017). Family functioning and children's sleep. *Child Development Perspectives, 11*, 264-269. doi:10.1111/cdep.12243

El-Sheikh, M., & Sadeh, A. (2015). I. Sleep and development: Introduction to the monograph. *Monographs of the Society for Research in Child Development, 80*, 1-14. doi:10.1111 /mono.12141

Enders, C. K. (2010). *Applied missing data analysis*. New York, NY: Guilford Press.

Enders, C. K., & Bandalos, D. L. (2001). The relative performance of full information maximum likelihood estimation for missing data in structural equation models. *Structural Equation Modeling, 8*, 430-457. doi:10.1207/S15328007SEM0803_5

Erath, S. A., Tu, K. M., Buckhalt, J. A., & El-Sheikh, M. (2015). Associations between children's intelligence and academic achievement: The role of sleep. *Journal of Sleep Research, 24*, 510-513. doi:10.1111/jsr.12281

Fraley, R. C., Roisman, G. I., & Haltigan, J. D. (2013). The legacy of early experiences in development: Formalizing alternative models of how early experiences are carried forward over time. *Developmental Psychology, 49,* 109-126. doi:10.1037/a0027852

Fredriksen, K., Rhodes, J., Reddy, R., & Way, N. (2004). Sleepless in Chicago: Tracking the effects of adolescent sleep loss during the middle school years. *Child Development, 75*, 84-95. doi:10.1111/j.1467-8624.2004.00655.x

Galland, B. C., Taylor, B. J., Elder, D. E., & Herbison, P. (2012). Normal sleep patterns in infants and children: A systematic review of observational studies. *Sleep Medicine Reviews, 16*, 213-222. doi:10.1016/j.smrv.2011.06.001

Geiser, C. (2012). *Data analysis with Mplus*. New York, NY: Guilford Press.

Goodlin-Jones, B. L., Tang, K., Liu, J., & Anders, T. F. (2008). Sleep patterns in preschool-age children with autism, developmental delay, and typical development. *Journal of the American Academy of Child & Adolescent Psychiatry*, *47*, 930-938. doi:10.1097/CHI.ObO13e3181799f7c

Goodnight, J. A., Bates, J. E., Staples, A. D., Pettit, G. S., & Dodge, K. A. (2007). Temperamental resistance to control increases the association between sleep problems and externalizing behavior development. *Journal of Family Psychology, 21*, 39-48. doi:10.1037/0893-3200.21.1.39

Hatzinger, M., Brand, S., Perren, S., von Wyl, A., Stadelmann, S., von Klitzing, K., & Holsboer-Trachsler, E. (2012). Pre-schoolers suffering from psychiatric disorders show increased cortisol secretion and poor sleep compared to healthy controls. *Journal of Psychiatric Research*, *46*, 590-599. doi:10.1016/j.jpsychires.2012.01.018

Hoffman, L. (2015). *Longitudinal analysis: Modeling within-person fluctuation and change*. New York, NY: Routledge.

Hsu, H.C. (2017). Association between night waking and child health during the first 3 years of life. *Journal of Developmental and Behavioral Pediatrics*, *38*, 215-223. doi:10.1097 /DBP.0000000000000428.

Iglowstein, I., Jenni, O. G., Molinari, L., & Largo, R. H. (2003). Sleep duration from infancy to adolescence: Reference values and generational trends. *Pediatrics, 111*, 302-307. Retrieved from http://pediatrics.aappublications.org/content/pediatrics/111/2/302.full.pdf

Jenni, O. G., Fuhrer, H. Z., Iglowstein, I., Molinari, L., & Largo, R. H. (2005). A longitudinal study of bed sharing and sleep problems among Swiss children in the first 10 years of life. *Pediatrics, 115*, 233-240. doi:10.1542/peds.2004-0815E

Jenni, O. G., & LeBourgeois, M. K. (2006). Understanding sleep-wake behavior and sleep disorders in children: The value of a model. *Current Opinion in Psychiatry, 19*, 282-287. doi:10.1097/01.yco.0000218599.32969.03

Jenni, O. G., Molinari, L., Caflisch, J. A., & Largo, R. H. (2007). Sleep duration from ages 1 to 10 years: Variability and stability in comparison with growth. *Pediatrics, 120*, e769-e776. doi:10.1542/peds.2006-3300

Kocevska, D., Muetzel, R. L., Luik, A.I., Luijk, M.P., Jaddoe, V. W., Verhulst, F.C., White, T., & Tiemeier, H. (2017). The developmental course of sleep disturbances across childhood relates to brain morphology at age 7: The generation R study. *Sleep*, *40*, zsw022. doi:10.1093 /sleep /zsw022.

Luke, D. A. (2004). *Multilevel modeling.* Thousand Oaks, CA:Sage.

Maas, C. J., & Hox, J. J. (2005). Sufficient sample sizes for multilevel modeling. *Methodology, 1,* 86-92. doi:10.1027/1614-2241.1.3.86

Magee, C. A., Gordon, R., & Caputi, P. (2014). Distinct developmental trends in sleep duration during early childhood. *Pediatrics, 133*, e1561-e1567. doi:10.1542/peds.2013-3806

Meltzer, L. J., Montgomery-Downs, H. E., Insana, S. P., & Walsh, C. M. (2012). Use of actigraphy for assessment in pediatric sleep research. *Sleep Medicine Reviews*, *16*, 463-475. doi:10.1016/j.smrv.2011.10.002

Miller, A. L., Seifer, R., Crossin, R., & Lebourgeois, M. K. (2015). Toddler's self-regulation strategies in a challenge context are nap-dependent. *Journal of sleep research, 24*, 279-287. doi:10.1111/jsr.12260

Mindell, J. A., & Owens, J. A. (2015). *A clinical guide to pediatric sleep: Diagnosis and management of sleep problems* (3rd ed.). Philadelphia, PA: Lippincott, Williams, & Wilkins.

Price, A. M., Brown, J. E., Bittman, M., Wake, M., Quach, J., & Hiscock, H. (2013). Children's sleep patterns from 0 to 9 years: Australian population longitudinal study. *Archives of Disease in Childhood*, *99*, 119-125. doi:10.1136/ archdischild-2013-304083

Sadeh, A. (2015). Sleep assessment methods. *Monographs of the Society for Research in Child Development, 80*, 33-48. doi:10.1111/mono.12143

Sadeh, A., Lavie, P., Scher, A., Tirosh, E., & Epstein, R. (1991). Actigraphic home-monitoring sleep-disturbed and control infants and young children: A new method for pediatric assessment of sleep-wake patterns. *Pediatrics, 87,* 494-499. Retrieved from http://pediatrics.aappublications.org/content/pediatrics/87/4/494.full.pdf

Scher, A., Epstein, R., & Tirosh, E. (2004). Stability and changes in sleep regulation: A longitudinal study from 3 months to 3 years. I*nternational Journal of Behavioral Development, 28*, 268-274. doi:10.1080/01650250344000505

Scher, A., Hall, W. A., Zaidman-Zait, A., & Weinberg, J. (2010). Sleep quality, cortisol levels, and behavioral regulation in toddlers. *Developmental Psychobiology, 52*, 44-53. doi:10 .1002/dev.20410

Scholle, S., Beyer, U., Bernhard, M., Eichholz, S., Erler, T., Graneß, P., ... Koch, G. (2011). Normative values of polysomnographic parameters in childhood and adolescence: Quantitative sleep parameters. *Sleep Medicine, 12*, 542-549. doi:10.1016/j.sleep.2010.11.011

Sheldon, S.H., 2006. Sleep in infants and children. In: T. Lee-Chiong (Ed.), *Sleep: A Comprehensive Handbook*. Hoboken, NJ: Wiley.

Silva, G. E., Goodwin, J. L., Parthasarathy, S., Sherrill, D. L., Vana, K. D., Drescher, A. A., & Quan, S. F. (2011). Longitudinal association between short sleep, body weight, and emotional and learning problems in Hispanic and Caucasian children. *Sleep, 34*, 1197-1205. doi:10.5665 /SLEEP.1238

Singer, J. D., & Willett, J. B. (2003). *Applied longitudinal data analysis: Modeling change and event occurrence.* New York, NY: Oxford University Press.

Sitnick, S. L., Goodlin-Jones, B. L., & Anders, T. F. (2008). The use of actigraphy to study sleep disorders in preschoolers: Some concerns about detection of nighttime awakenings. *Sleep, 31,* 395-401. doi:10.1093/sleep/31.3.395

So, K., Buckley, P. A. T., Adamson, T. M., & Horne, R. S. (2005). Actigraphy correctly predicts sleep behavior in infants who are younger than six months, when compared with polysomnography. *Pediatric Research, 58*, 761-765. doi:10.1203/01.PDR.0000180568 .97221.56

Staples, A. D., Bates, J. E., & Petersen, I. T. (2015). Ix. Bedtime routines in early childhood: Prevalence, consistency, and associations with nighttime sleep. *Monographs of the Society for Research in Child Development, 80*, 141-159. doi:10.1111/mono.12149

Sung, M., Adamson, T. M., & Horne, R. S. (2009). Validation of actigraphy for determining sleep and wake in preterm infants. *Acta Paediatrica, 98*, 52-57. doi:10.1111/j.1651-2227.2008 f.01002.x

Thorpe, K., Staton, S., Sawyer, E., Pattinson, C., Haden, C., & Smith, S. (2015). Napping, development and health from 0 to 5 years: A systematic review. *Archives of Disease in Childhood, 100*, 615-622. doi:10.1136/archdischild-2014-307241

Touchette, E., Côté, S. M., Petit, D., Liu, X., Boivin, M., Falissard, B., ... Montplaisir, J. Y. (2009). Short nighttime sleep-duration and hyperactivity trajectories in early childhood. *Pediatrics, 124*, 985-993. doi:10.1542/peds.2008-2005

Touchette, E., Petit, D., Tremblay, R. E., Boivin, M., Falissard, B., Genolini, C., & Montplaisir, J.Y. (2008). Associations between sleep duration patterns and overweight/obesity at age 6. *Sleep, 31*, 1507-1514. doi:10.1093/sleep/31.11.1507

Vaughn, B., El-Sheikh, M., Shin, N., Elmore-Staton, L., Krzysik, L., & Monteiro, L. (2011). Attachment representations, sleep quality and adaptive functioning in preschool age children. *Attachment and Human Development*, *13*, 525-540. doi:10.1080/14616734.2011.608984

Ward, T. M., Gay, C., Anders, T. F., Alkon, A., & Lee, K. A. (2008). Sleep and napping patterns in 3-to-5-year old children attending full-day childcare centers. *Journal of Pediatric Psychology, 33,* 666-672. doi:10.1093/jpepsy/jsm102

Weinraub, M., Bender, R. H., Friedman, S. L., Susman, E. J., Knoke, B., Bradley, R., ... Williams, J. (2012). Patterns of developmental change in infants' nighttime sleep awakenings from 6 through 36 months of age. *Developmental Psychology, 48*, 1511-1528. doi:10.1037/a0027680

Williams, K. E., Nicholson, J. M., Walker, S., & Berthelsen, D. (2016). Early childhood profiles of sleep problems and self-regulation predict later school adjustment. *British Journal of Educational Psychology*, *86*, 331-350. doi:10.1111/bjep.12109

Table 1

Descriptive Statistics, Correlations across Time Points, and Inter-Correlations among Variables

Age	M (SD)	Range	Correlations across age: 2 yrs	3 yrs	4 yrs	Inter-correlations among sleep variables: Nighttime sleep	Daytime sleep	Total daily sleep duration	Proportion of nighttime sleep	Sleep Efficiency
Nighttime sleep duration										
2 yrs	564.94 (59.82)	389.25-678.34	--	.09	.30*	--	-.02	.75***	.27*	.71***
3 yrs	560.89 (44.87)	466-666.50	--	--	.46**	--	-.24^{t}	.54***	.38**	.57***
4 yrs	532.50 (46.16)	414-646.67	--	--	--	--	-.48***	.45**	.58***	.31*
Daytime sleep duration										
2 yrs	124.28 (52.57)	10-225	--	.23	-.02	--	--	.66***	-.93***	.07
3 yrs	117.42 (52.52)	0-228	--	--	.64***	--	--	.69***	-.98***	.05
4 yrs	92.96 (51.99)	4-183.50	--	--	--	--	--	.55***	-.99***	.23^{t}
Total daily sleep duration										
2 yrs	687 (77.66)	542-851.50	--	.17	.20	--	--	--	-.45***	.57***
3 yrs	679.53 (60.94)	507.75-802.75	--	--	.12	--	--	--	-.57***	.48***
4 yrs	644.61 (50.53)	527.33-760.33	--	--	--	--	--	--	-.47***	.57***
Proportion of nighttime sleep										
2 yrs	82.33 (6.75)	67.20-98.15	--	.24	.13	--	--	--	--	.11
3 yrs	83.08 (7.10)	69-100	--	--	.67***	--	--	--	--	.05
4 yrs	86.35 (7.63)	71.46-100	--	--	--	--	--	--	--	-.23^{t}
Sleep efficiency										
2 yrs	90.61 (7.09)	67.03-99.57	--	.05	.12	--	--	--	--	--
3 yrs	94 (5.52)	70.93-100	--	--	.22	--	--	--	--	--
4 yrs	94.75 (4.39)	76.57-100	--	--	--	--	--	--	--	--

$^{t}p < .10$. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$. Note. SD = Standard deviation.

Table 2

Intercept-Only Models of Children's Sleep during the Preschool Period

	Nighttime duration	Daytime duration	Total daily sleep duration	Proportion of nighttime sleep	Sleep efficiency
Within					
Variances	0.58^{**}	0.65^{**}	1.14^{**}	140.65^{**}	36.46^{**}
	(0.09)	(0.12)	(0.18)	(19.69)	(4.98)
Between					
Means	9.34	1.88	11.19	81.31	92.94
	(0.06)	(0.07)	(0.09)	(1.48)	(0.44)
Variances	0.15^{*}	0.15	0.11	151.21^{**}	1.80
	(0.08)	(0.12)	(0.14)	(27.65)	(3.57)
Goodness-of-fit					
LL	-263.41	-229.07	-264.70	-763.25	-678.39

$^{*}p < .05$. $^{**}p < .001$. Note. Standard errors are within parentheses; LL = log likelihood.

al Growth Models of Children's Sleep during the Preschool Period

		Nighttime duration	Daytime duration	Total daily sleep duration	Proportion of nighttime sleep	Sleep efficiency
model		Model A	Model A	Model B	Model A	Model B
	Par					
s						
s, π_{0i}						
(2 years)	γ_{00}	9.45**	2.22**	11.63**	81.18**	90.55**
		(0.10)	(0.12)	(0.17)	(0.96)	(0.80)
nge, π_{1i}						
ope	γ_{10}	-0.09	-0.29**	-0.37**	2.23**	2.14**
		(0.07)	(0.08)	(0.10)	(0.63)	(0.49)
n slope ic)	γ_{20}					
mponents						
erson (residual)	σ_E^2	0.56**	0.54**	0.81**	37.53**	26.58**
		(0.08)	(0.10)	(0.17)	(6.80)	(3.50)
status	σ_0^2	0.16*	0.22*	0.97*	13.53^{t}	21.40*
		(0.08)	(0.11)	(0.43)	(6.93)	(8.92)
f change	σ_1^2			0.17		3.87
				(0.19)		(2.61)
ercept ce	σ_{01}			-0.40		-9.10^{t}
				(0.27)		(4.74)
s-of-fit	LL	-254.63	-218.45	-248.84	-569.84	-646.81

.05. ** $p < .001$. Note. Standard errors are within parentheses; Par = parameters; LL = log likelihood; Model A: fixed linear el B: random linear model.

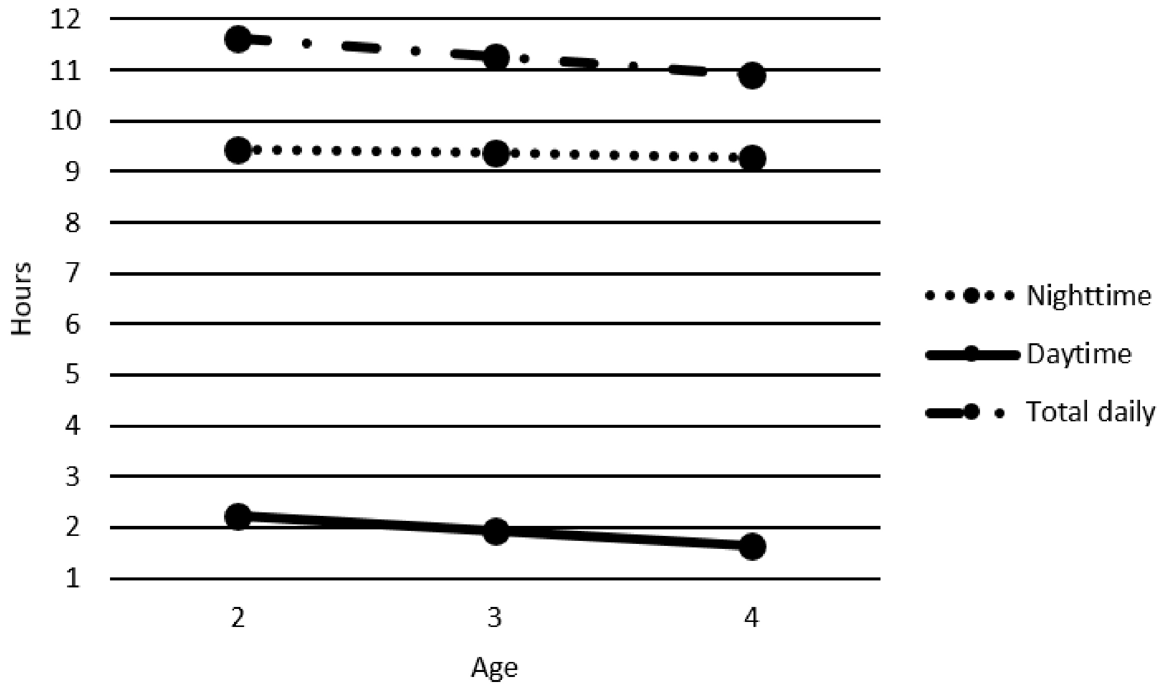

Figure 1. Developmental change in nighttime, daytime, and total daily sleep duration.

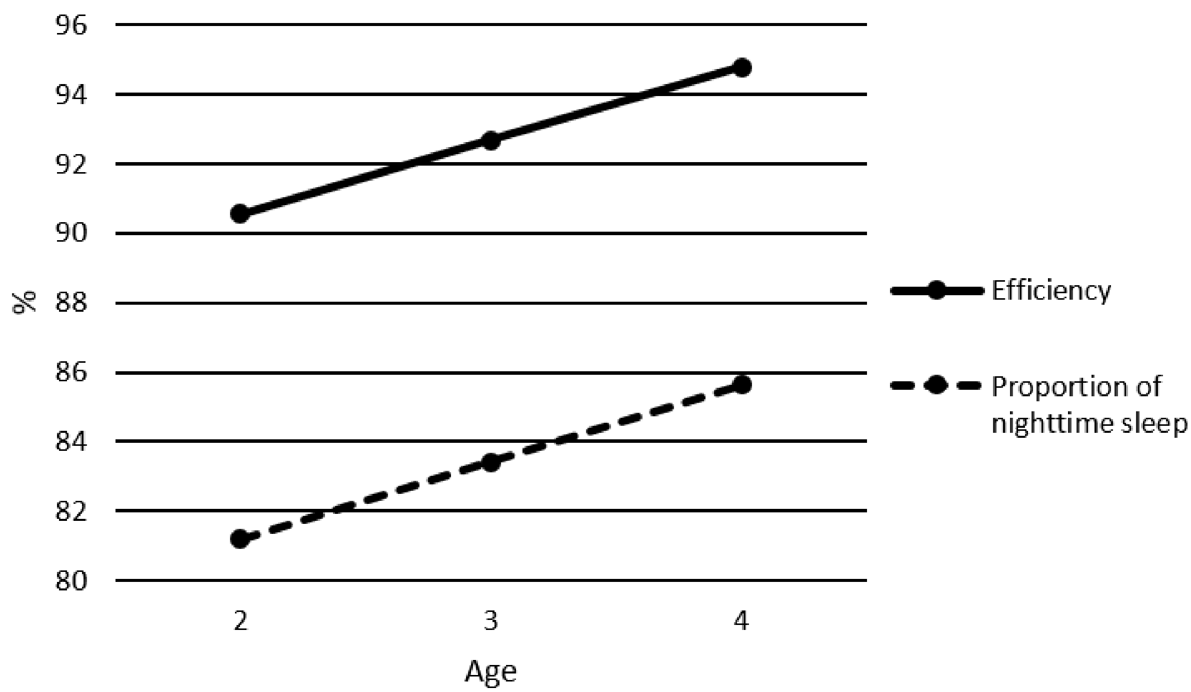

Figure 2. Developmental change in proportion of nighttime sleep and sleep efficiency.

Article 3

Quality of father–child relationships as a predictor of sleep developments during preschool years

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Quality of father–child relationships as a predictor of sleep developments during preschool years

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Abstract

Substantial developmental changes in sleep occur during the preschool period, but few studies have investigated the factors that forecast these developments. The aim of this study was to examine whether three aspects of father-child relationships in toddlerhood predicted individual differences in developmental patterns of change in five actigraphy-derived sleep variables during the preschool period (2 to 4 years). Although some trend-level results were found with the general quality of father–child interactions, the clearest findings emerged with paternal mind-mindedness. Multilevel growth modelling revealed that children whose father made more mind-related comments during father–child interactions had a higher proportion of sleep taking place during nighttime and shorter daytime and total sleep duration at 2 years. This was, however, followed by a relative levelling off (i.e., less rapid change) of these sleep features between 2 and 4 years. Given previous studies documenting that nighttime sleep proportion increases while daytime and total sleep duration decrease during preschool years, the findings suggest that children who are exposed to more paternal mind-mindedness may reach more mature sleep patterns earlier in development.

Keywords: father-child relations, sleep, child development, actigraphy

Quality of father–child relationships as a predictor of sleep developments during preschool years

Important developmental changes in sleep occur during the preschool period, including an increase in sleep quality and consolidation along with a decrease in sleep duration (Acebo et al., 2005; Tétreault, Bernier, Matte-Gagné, & Carrier, 2019). However, few longitudinal studies have documented these developments, and even less is known about the factors that may predict individual differences in these age-related changes. As the quality of parent-child relationships has frequently been associated with children's sleep at specific ages (Bernier, Bélanger, & Tétreault, 2019; El-Sheikh & Kelly, 2017), parent-child relationships may be promising predictors of sleep trajectories during the preschool period. Nonetheless, very few studies have examined these associations, particularly with father–child relationships. The current study aimed at investigating whether the quality of early father–child relationships predicted developmental trajectories of objectively assessed sleep quality, consolidation, and duration among preschool-aged children.

Parent-child relationships

A feeling of physical and emotional security is essential for sleep, given that sleep involves a dramatic decrease in alertness (Dahl & El-Sheikh, 2007). However, it has been suggested that bedtime may be a time of heightened anxiety for young children, particularly because of the darkness and prolonged separation from parents (Keller, 2011). In this context, parents can act as external regulators of child affect, promoting feelings of security and gradually supporting the self-regulation capacity (Calkins & Hill, 2007) that is required to surrender alertness and therefore to fall and stay asleep. Parent-child interactions, including those occurring during the day, are well documented contributors to the emotional quality of parent-child relationships and children's sense of security (De Wolff & Van IJzendoorn, 1997), and may thus serve to promote the optimal regulation of children's sleep-wake cycles.

Father–child relationships. Compared to mother–child relationships, father–child relationships have received little attention in relation to child sleep. This is in spite of the fact that in recent decades, fathers have become increasingly involved in child care (Schoppe-Sullivan & Fagan, 2020), notably during the toddlerhood and preschool periods (National Institute of Child Health and Human Development Early Child Care Research Network, 2000) and including in bedtime and nighttime care (e.g., Goodlin-Jones, Burnham, Gaylor, & Anders, 2001; Tikotzky, Sadeh, & Glickman-Gavriel, 2011). Fathers are also affected by their children's sleep. For instance, fathers of infants who frequently wake up at night have lower-quality sleep themselves (McDaniel & Teti, 2012; Sinai & Tikotzky, 2012). Moreover, it has frequently been shown that father–child relationships contribute to many aspects of children's social, behavioral, cognitive, and emotional development (see Schoppe-Sullivan & Fagan, 2020, and Volling & Cabrera, 2019), including children's sleep (see Bernier et al., 2019). Fathers may even play a special role in children's sleep due to their unique parenting style (Sadeh, Tikotzky, & Scher, 2010). For instance, fathers have been found more likely than mothers to endorse a limit-setting approach when faced with children's sleep difficulties (Sadeh, Flint-Ofir, Tirosh, & Tikotzky, 2007).

In the last ten years, studies have begun to examine the role of father–child relationships in children's sleep. Tikotzky et al. (2011) found that higher paternal involvement in infant care at 1 month and 6 months (during the day and night) was associated with more consolidated sleep (fewer nocturnal awakenings) at 6 months, as measured by actigraphy and parental reports. Higher paternal involvement at 1 and 6 months was also, however, associated with shorter sleep duration at 6 months. In a second study, higher overall (i.e., during the day and night) paternal involvement in infant care at 3 and 6 months as well as higher nighttime paternal involvement at 6 months predicted more consolidated sleep at 6 months, assessed with actigraphy (Tikotzky et al., 2015). Studying older children, Millikovsky-Ayalon, Atzaba-Poria and Meiri (2015) found that fathers of 1-to-3-

year-olds who were considered by their parents to have significant sleep problems showed lower levels of involvement in child care and lower sensitivity to the child during a meal interaction. Rhoades et al. (2012) found that fathers' hostile parenting at 27 months predicted parent-reported child sleep problems at 4.5 years. Moreover, the effects of hostile parenting on child sleep were significantly greater for fathers than mothers. In another study among children aged between 3 and 5 years, quality of father–child interactions was not associated with parent-reported child sleep duration, but was significantly associated with parent-reported child sleep problems (Dubois-Comtois, Pennestri, Bernier, Cyr, & Godbout, 2019). Still at preschool age, a study by our team (Bordeleau, Bernier, & Carrier, 2012) found that the quality of father–child interactions at 18 months was positively associated with sleep consolidation at ages 3 and 4, as reported by mothers using a sleep diary. With the same sample, we found that higher levels of paternal self-reported general involvement in child care at 2 years were associated with longer nocturnal sleep at 3 years, this time measured by actigraphy (Bernier, Tétreault, & Bélanger, 2017). At school age, Keller and El-Sheikh (2011) found that father–child attachment at age 8 predicted self-reported sleep at age 10, but did not predict actigraphy-derived sleep. Finally, Bell and Belsky (2008) found that mothers of children whose father was absent from the home reported more sleep problems in their 8-11-year-old child.

Overall, a relatively modest but growing body of empirical literature suggests that father–child relationships may influence children's sleep at specific ages. However, no study to our knowledge has documented such associations in relation to the substantial developmental changes in sleep that occur during the preschool period, although these changes, in and of themselves, are a central feature of sleep among preschoolers. Also, the majority of existing studies were based on a single indicator of the father–child relationship, although the review presented above suggests that different dimensions of father–child relationships (degree of paternal involvement, specific paternal behaviors, general relational quality) may be associated with children's sleep.

Among dimensions of father–child relationships that have not yet been studied in association with children's sleep, paternal mind-mindedness, which consists of the tendency to comment verbally on the child's mental activity during parent-child interactions, appears to be a relevant behavior to consider. It has been proposed that by providing labels for the child's thoughts and affective states, mind-related comments are one way in which parents may facilitate self-regulation in their children and indeed, numerous studies have shown that greater parental mind-mindedness during parent-child interactions is associated with several positive developmental outcomes, including child self-regulation and sleep (see McMahon & Bernier, 2017 for a review). Although both parents can display mind-mindedness at comparable frequencies (Lundy, 2013; Zeegers et al., 2018), almost all studies to date were centered on maternal mind-mindedness. Accordingly, the current study considered paternal mind-mindedness along with paternal involvement in child care and general quality of father–child interactions as potential predictors of sleep developments during preschool years.

Patterns of development in sleep across the preschool period

Beyond studying sleep patterns at a given age, it is also important to examine how these patterns unfold through a given developmental period. This enables the study of important aspects of sleep development, for example with regard to the timing and evolution of sleep difficulties and how changes in sleep relate to changes in other spheres of development or are predicted by child and environmental factors (El-Sheikh & Kelly, 2017). Longitudinal studies supplemented by growth modeling approaches offer information about developmental patterns in sleep across time (referred to as sleep growth curves), a component of child development that remains ill understood (El-Sheikh & Kelly, 2017). These statistical approaches also allow for comparison of individuals on these developmental patterns (i.e., between-individual differences in within-individual rates of change) and for the identification of predictors of these individual differences.

Relatively few studies have used such approaches to formally describe and predict patterns of development in preschoolers' sleep, despite the fact that important developmental changes in sleep (i.e., increased sleep quality and consolidation as well as decreased sleep duration) take place during the preschool period. Touchette et al. (2008, 2009) studied nighttime sleep duration trajectories between 2 and 6 years and found that children following distinct trajectories differed on factors like maternal immigration status and education, family income, and some parental behaviors (e.g., parental presence at bedtime and mothers' self-reported overprotection of the child). Magee, Gordon, and Caputi (2014) reported that mothers' employment status, family income, and family size were associated with different trajectories of total daily sleep duration between 0 and 7 years. Weinraub et al. (2012) observed that children with distinct nocturnal awakening trajectories between 6 and 36 months differed on breastfeeding, maternal depressive symptoms, spousal health problems, family size, and number of hours spent at daycare, whereas Kocevska et al. (2017) found that maternal education and affective symptoms were associated with different trajectories of sleep disturbances between 2 months and 6 years. Williamson, Mindell, Hiscock, and Quach (2019) studied sleep problems trajectories from birth to 11 years and identified that distinct trajectories were associated with parent-reported family (e.g., parental psychological distress, marital hostility), parenting (e.g., low warmth, hostility), and socioeconomic factors. Finally, Plancoulaine et al. (2018) reported that distinct trajectories of nighttime sleep duration between 2 and 6 years were associated with maternal age, working status, and smoking, parent-reported child temperament, and parental presence at bedtime.

Overall, different family factors (including distal factors like parental employment, immigration status or income) are associated with differences in children's sleep developments. Given that children, especially young children, are generally not aware of distal factors, one may expect that such factors come to affect child sleep through the family context and especially parents' actual interactions with their child. However, very few studies thus far have focused on parenting or parent-child relationships, and even less on father–child relationships, as predictors of sleep developments. Studies that have considered parental behaviors in the prediction of child sleep trajectories measured limited indicators of parental behaviors (e.g., parental presence at bedtime) and their measures were parent-reported. Moreover, all aforementioned studies focused on only one sleep variable and measured children's sleep with parental reports. Such measures are susceptible to different biases inherent to the parent's psychological state, compliance, and the burden associated with completing the questionnaire (Sadeh, 2015). In a previous article by our group (Tétreault et al., 2019), the developmental trajectories characterizing five sleep variables assessed objectively with actigraphy between ages 2 and 4 were described using a growth curve modeling approach. We observed a linear decrease in daytime, total, and nighttime sleep duration as well as a linear increase in sleep efficiency and proportion of nighttime to total sleep. In the current study, different aspects of the quality of father–child relationships were considered as potential predictors of individual differences in these sleep growth curves.

The current study

The current longitudinal study investigated whether the quality of father–child relationships in toddlerhood predicted developmental patterns of change in five actigraphic sleep variables across the preschool years. To our knowledge, this study is the first to aim at predicting individual differences in developments in actigraphy-derived sleep variables among children of any age, besides Volkovich, Bar-Kalifa, Meiri, and Tikotzky (2018) who investigated sleep trajectories of co-sleeping versus solitary sleeping infants. A multilevel modeling (MLM) framework was used to examine whether three aspects of father–child relationships, namely paternal mind-mindedness, overall quality of father–child interactions, and paternal involvement, predicted inter-individual differences in initial status and rate of change in sleep trajectories. As explained above, paternal mind-mindedness refers to the father's tendency to comment appropriately on the child's presumed mental states (Meins, Fernyhough, Fradley, & Tuckey, 2001). The overall quality of father–child interactions represents the degree to which interactions are characterized by harmonious communication, mutual cooperation, and an emotionally positive atmosphere (Aksan, Kochanska, & Ortmann, 2006). Finally, paternal involvement refers to the degree to which fathers are implicated in childrearing (e.g., caregiving, play activities, emotional support, and discipline; Cabrera, Tamis-LeMonda, Bradley, Hofferth, & Lamb, 2000). These three aspects of father–child relationships represent different ways in which fathers may act as external regulators of children's emotions and behaviors, gradually facilitating self-regulatory capacities. They can thus globally be expected to promote optimal regulation of child sleep-wake cycles, including sleep duration, quality, and consolidation. However, considering the lack of research on the subject, no precise hypothesis was formulated about the specific predictive value of each of these aspects of father–child relationships in relation to different indicators of sleep developments during preschool years.

Method

Participants

The sample was composed of 67 children (34 girls) for whom sleep trajectories between 2 and 4 years were estimated and paternal mind-mindedness and quality of father–child interactions were assessed at 18 months. Among them, 63 fathers (31 girls) reported on their level of involvement with their child at age 2. Families were recruited in the context of a longitudinal study pertaining to parent-child relationships and child development (Bernier, Beauchamp, & Cimon-Paquet, 2020). They were recruited in a large metropolitan area using birth lists provided by the Ministry of Health and Social Services. Children were born after a full-term pregnancy and did not have any known physical or psychological disabilities (known at the time of recruitment when children were 7-8 months old). Mothers' written consent was obtained before the study began and all study procedures were approved by our university's ethics committee. At the time of recruitment, fathers were aged between 26 and 58 years (*M* = 34.9, *SD* = 6.4), had 16 years of education on average (*SD* = 2.4), and most were White (87.3%). Mothers were between 24 and 45 years (*M* = 32.3, *SD* = 4.4), had 16 years of education on average (*SD* = 2.0), and were mostly White (94.9%). Families' annual income varied from less than $20,000 to over $100,000 (in Canadian dollars), with a mean in the $60,000 – $79,000 bracket.

Procedure

When children were aged 18 months (*M* = 18.3 months; *SD* = 0.85), they came to our laboratory with their fathers. A 10-minute father-child free play sequence was videotaped, which was later rated for paternal mind-mindedness as well as for overall quality of father–child interactions by independent teams of coders. Mind-mindedness coders were unaware of how overall quality of interactions was coded, and vice-versa. Fathers were asked to play as usual with their toddler, using a set of toys put at their disposal. The free-play context was chosen based on studies suggesting that explorative play is the main component of father–child interactions (Cabrera & Roggman, 2017; Schoppe-Sullivan & Fagan, 2020). When children were aged 2 years (*M* = 25.2 months; *SD* = 1.0), we asked their fathers to fill in the Montreal Father's Involvement Questionnaire (below) and to return it by mail to our laboratory.

Children's sleep was assessed on three consecutive days when they were aged 2 (23 to 28 months), 3 (35 to 38 months; *M* = 36.7 months) and 4 years (47 to 51; *M* = 48.8 months). We chose a three-night duration in order to reduce child and family burden with the aim of maximizing compliance. Although a minimum of five nights of recordings is preferable to obtain optimally reliable actigraphic data, acceptable reliability can be achieved with three nights (see Acebo et al., 1999). Following home visits, families were left with an actigraph and a sleep diary and instructed on how to use them. It was specified that the child should wear the actigraph during three days where he or she had a rather usual routine. Families were offered $20 to compensate them for their time.

Measures

Paternal mind-mindedness. Paternal mind-mindedness was assessed at 18 months based on the 10-min father–child free-play session described above. These videotaped interactions were rated by a trained assistant using Meins et al.'s (2001) coding system. There were five different categories of mind-related comments: (a) desires and preferences; (b) cognitions (knowledge, decisions, etc.); (c) emotions; (d) epistemic states (playing games, joking); (e) talking on the child's behalf. Each mind-related comment was then rated as appropriate or non-attuned (Meins et al., 2001). A comment was considered appropriate if it met at least one of the following criteria: (a) the examiner agrees with the comment on the child's state of mind; (b) the comment is clearly related to a past, present, or future event; and (c) the comment indicates how to proceed after a pause in the interaction. Contrastingly, non-attuned comments seem to be unrelated to child cues and may cut across the child's apparent interests. Non-attuned mind-related comments were very rare in this community sample (over 90% of fathers made none at all) and were therefore not considered further. The mind-mindedness score consisted of the total number of appropriate mind-related comments the father made during the interaction. A second trained rater independently coded 30% of the sample. Interrater reliability was high, intraclass correlation (*ICC*) = .94.

Father–child interactions. Using the same free-play session, the quality of father–child interactions was rated using the Mutually Responsive Orientation scale (MRO; Aksan et al., 2006), an observational measure of the overall quality of parent–child interactions. Three of the four original MRO subscales were assessed: Harmonious Communication (the degree to which communication flows smoothly between parent and child); Mutual Cooperation (the partners' capacity to resolve conflicts and openness to each other's influence); and Emotional Ambiance (the degree to which the partners share an emotionally positive atmosphere and appear to enjoy being together). The Coordinated Routine subscale was not used because it refers to activities that become scripted over time, and was thus not well suited to the free-play context. In line with Aksan et al. (2006), the scores of the three subscales were averaged into a global score representing the quality of father–child interactions ($\alpha = .98$). Scores varied between 1 (disconnected, unresponsive, and/or affectively negative interaction) and 5 (mutually responsive, harmonious, cooperative, and/or affectively positive interaction). Randomly selected videotapes (21%) were coded independently by two raters. Interrater reliability was excellent (*ICC* = .89). The MRO has demonstrated excellent psychometric qualities when used with young children, including toddlers, and their mothers and fathers (Aksan et al., 2006; Kochanska, Aksan, Prisco, & Adams, 2008). It possesses excellent predictive validity (Kochanska & Murray, 2000; Kochanska et al., 2008) and discriminant validity (Lalonde, Bernier, Beaudoin, Gravel, & Beauchamp, 2016).

Paternal involvement. When children were 2 years old, fathers reported on their involvement with their child by completing the Montreal Father's Involvement Questionnaire (MFIQ; Paquette, Bolté, Turcotte, Dubeau, & Bouchard, 2000), which is composed of 56 items answered on a 5-point (1 = *never* to 5 = *very often*) or 6-point Likert scale (1 = *never* to 6 = *every day*). The MFIQ consists of seven subscales: Emotional support (behaviors that communicate love and protection to the child, e.g., cuddling or consoling; 12 items); Opening to the world (promoting exploration and challenge, e.g., initiating the child to new games or new places; 9 items); Basic care (bathing, dressing, or feeding the child; 9 items); Physical play (e.g.,tickling, rough-and-tumble play; 7 items); Evocation (evoking the absent child, e.g., telling stories about him or her or reminiscing about when he or she was younger; 6 items); Discipline (correcting the child's misbehavior or teaching age-appropriate behavior; 4 items); and Home chores (participating in household tasks such as cooking, cleaning, etc.; 9 items). Paquette et al. (2000) reported that the seven subscales showed satisfactory internal consistency (Cronbach's α ranging from .72 to .86) and one-month test–retest reliability (*r*'s from .50 to .75). In the present study, the means of the seven scales were summed into one overall paternal involvement score (α = .82), leading to a maximum total score of 39.

Actigraphy and sleep diary. Children wore an actigraph (Mini-Mitter® Actiwatch, Respironics; AW-64), a small monitor that continuously records body movements through an accelerometer, around the ankle or wrist. They wore the actigraph for 72 hours, except when they were in contact with water (e.g., when taking a bath). Activity level was recorded in 30-second epochs and then converted into estimates of sleep and wake periods. As young children present higher levels of motor activity during sleep, actigraphy tends to overestimate their night awakenings (Meltzer, Montgomery-Downs, Insana, & Walsh, 2012). To overcome this issue, data were analyzed initially with the manufacturer's low sensitivity threshold algorithm (80; more appropriate for young children's motor activity). A "smoothing" algorithm, developed to address the problem of night waking overestimation, was applied in a second step. This smoothing method has been validated against videosomnography (Sitnick, Goodlin-Jones, & Anders, 2008) and home-based polysomnography (Bélanger, Bernier, Paquet, Simard, & Carrier, 2013). The scoring procedure led to the estimation of five sleep variables: (a) nighttime sleep duration (number of minutes scored as sleep between nighttime sleep onset and offset); (b) daytime sleep duration; (c) total sleep duration over 24 hours (nighttime + daytime sleep duration); (d) proportion of nighttime sleep (percentage of total sleep occurring at night, which constitutes an indicator of sleep distribution) and (e) sleep efficiency ([number of minutes scored as sleep between nighttime sleep onset and offset/ total minutes between sleep onset and offset] x 100). Each of these variables was averaged over the three days of assessment. Actigraphy allows for the collection of objective sleep data in the natural environment with low levels of intrusion. Its validity for assessing sleep in children has been extensively demonstrated (Acebo et al., 1999; Sadeh, Lavie, Scher, Tirosh, & Epstein, 1991; Sung, Adamson & Horne, 2009). The brand and model of actigraph used in this study show good to high correspondence (77-98% across sleep estimates) with polysomnography for preschoolers, with no distinction according to location (ankle or wrist; Bélanger et al., 2013).

During the same 72 hours when the child was wearing the actigraph, the mother had to complete a sleep diary in order to confirm the validity of actigraphic data and allow us to verify the absence of any artifact (e.g., movement induced by an external object such as a stroller erroneously considered as awakening; child taking off the actigraph). She noted, on a timeline of 24 hours divided into epochs of 30 minutes, all periods when the child was asleep, where he or she was sleeping, and indicated any particular events (e.g., visitors staying late at night, the child taking medication or being ill) that could have interfered with his or her sleep. To minimize memory biases, the mother was asked to complete the sleep diary in real time (i.e., as the day unfolded rather than retrospectively at the end of the three-day period). When children attended daycare, the mother enquired about nap periods at the end of each day with the childcare worker and noted these on the diary. To ensure maximally reliable data, specific days of assessment were discarded when information reported on the sleep diary suggested that actigraphy data might include artifacts or be otherwise invalid.

Analytic strategy

Growth curves were fitted in Mplus 7.4 using a multilevel modeling (MLM) framework in order to describe and predict within-individual patterns of change in child sleep across time. MLM can easily handle issues associated with small samples (30–50 participants are sufficient with as many as five predictors), partially missing data, and unequally spaced time points (Burchinal, Nelson, & Poe, 2006; Singer & Willett, 2003), and therefore was well suited to this study. MLM entails using each child's precise age in months at each time point, and thus allows for flexibly handling varying time scores across children while taking advantage of the full spectrum of ages available (here, 22 through to 51 months of age). In the MLM framework, repeated observations are treated as nested within individuals and change is modeled on two levels: level 1 represents within-person change over time and level 2 estimates the degree to which change differs across individuals (between-persons; Singer & Willett, 2003). First, one trajectory across time per child is modeled, and then these trajectories are averaged, revealing how each variable develops on average (the average intercept and the average slope for the sample) and how each child varies around the average. Whereas the intercept reflects the mean group value at the starting point, the slope reflects the average yearly developmental change. To handle missing data, we used the full information maximum likelihood (FIML) estimator, which is well demonstrated as superior to classical methods for dealing with missing data (e.g., listwise and pairwise deletion; see Enders, 2010).

The average trajectory of each sleep variable from ages 2 to 4 was first established as described in Tétreault et al., 2019. The average initial status and rate of change for each sleep variable are displayed in Table 1 along with descriptive statistics for the predictor variables. Next, a series of conditional growth curve models were fitted in order to investigate the extent to which individual differences in growth curve estimates (intercept and slope) could be explained by indicators of father–child relationships. Continuous predictors were mean-centered for ease of interpretation. Consequently, the intercept represents the estimated initial status for a child with an average score on that predictor. With the aim of ensuring the specificity of the predictions, potential covariates that have frequently been associated with parent-child relationships or child sleep (child sex and family socioeconomic status) were entered first in the growth models. The three indicators of father–child relationships were entered next as predictors of the intercept and slope of each sleep variable. To preserve statistical power, the effects of the predictors were first examined separately. In a last step, only the significant (or marginal) effects were retained and entered simultaneously in the final models.

Results

All variables showed normal or near-normal distributions. Intercorrelations among covariates and potential predictors are presented in Table 2. Covariates were not associated with predictors, except for child sex, which was significantly associated with paternal involvement (p = .001): fathers reported to be more involved with boys than girls. Predictors showed small intercorrelations (*r*'s between .05 and .13, *ns*). The results of the growth curve models assessing the associations between the predictors and child sleep trajectories after controlling for child sex and family socioeconomic status are presented in Table 3 and described below. Given that sleep variables are not independent (e.g., total sleep is linearly dependent on nighttime and daytime sleep), the results are presented by predictor.

Paternal mind-mindedness

The models showed that after accounting for child sex and family socioeconomic status, paternal mind-mindedness was significantly and negatively associated with the intercept of daytime and total daily sleep duration and significantly and positively associated with the intercept of proportion of nighttime sleep. Higher paternal mind-mindedness predicted shorter daytime (B = -.35, p = .044) and total daily (B = -.46, p = .013) sleep duration at age 2, such that every one-standard-deviation increase in mind-mindedness was associated with a 21-minute (0.35 hours) decrease in daytime sleep and a 28-minute (0.46 hours) decrease in total daily sleep at 2 years. Higher mind-mindedness also predicted a higher age-2 intercept for proportion of nighttime sleep (B = .25, p = .043), whereby every one-standard-deviation increase in mind-mindedness was associated with a 0.25% increase in proportion of nighttime sleep at 2 years.

In addition, paternal mind-mindedness was marginally and positively associated with the slope of daytime and total sleep duration, and significantly and negatively associated with the slope of proportion of nighttime sleep, over and above child sex and family socioeconomic status. Because the slopes for sleep duration are negative (indicating an age-related decrease), corresponding coefficients must be interpreted in a counter-intuitive way: positive coefficients indicate that the predictor is related to a *slower decrease* in sleep duration, and negative coefficients indicate that the predictor is related to a *faster decrease* in sleep duration. Thus, higher mind-mindedness predicted a marginally slower decline in both daytime (B = .31, p = .093) and total (B = .41, p = .056) sleep duration between ages 2 and 4. Every one-standard-deviation increase in mind-mindedness was associated with a 18.6-minute (0.31 hours) slower annual decrease in daytime sleep duration and a 24.6-minute (0.41 hours) slower annual decrease in total daily sleep duration. Higher mind-mindedness also predicted a significantly slower increase in proportion of nighttime sleep (B = -.24, p = .005) between ages 2 and 4, whereby every one-standard-deviation increase in mind-mindedness was associated with a 0.24% slower increase in proportion of nighttime sleep. To further probe the developmental meaning of these results, we conducted follow-up analyses in which we moved the intercept (centered time) at 3 and at 4 years. These analyses revealed that mind-mindedness was not predictive of any sleep intercept at 3 (ps between .88 and .98) or 4 years (ps between .09 and .21).

Finally, mind-mindedness was not predictive of the intercept or slope of neither nighttime sleep duration nor sleep efficiency.

Father–child interactions

The overall quality of father–child interactions was marginally and negatively associated with the intercept of nighttime sleep duration: over and above child sex and family socioeconomic status, higher quality of father–child interactions predicted a lower age-2 intercept (B = -.35, p = .05).

Every one-standard-deviation increase in quality of father–child interactions was associated with a 21-minute (0.35 hours) decrease in nighttime sleep duration at 2 years.

The quality of father–child interactions was also marginally and positively associated with the slope of nighttime sleep duration, such that higher quality of interactions predicted a slower decrease ($B = .22$, $p = .07$) in nighttime sleep duration. Every one-standard-deviation increase in quality of interactions was associated with a 13.2-minute (0.22 hours) slower annual decrease in nighttime sleep duration.

The quality of father–child interactions was, however, not associated with the growth curve parameters of other sleep variables (daytime and total daily sleep duration, proportion of nighttime sleep, or sleep efficiency).

Paternal involvement

Father involvement was not significantly associated with the growth parameters of any sleep variable.

Final predictive models

Since there was no overlap between the predictors (with mind-mindedness and father–child interactions being associated with different sleep growth curve estimates, as described above), it was not justified to enter them together in the same models; consequently, the final models retained are those presented above and in Table 3, each including one paternal predictor along with the covariates.

Discussion

The aim of this study was to examine whether three aspects of the quality of father–child relationships in toddlerhood predicted individual differences in developmental patterns of change in five actigraphic sleep variables during the preschool period. Some trend-level results were found with the general quality of father–child interactions, but the clearest findings emerged with mind-

mindedness. Findings suggested that children whose father made more appropriate mind-related comments while playing with them at 18 months had a greater proportion of nighttime sleep at 2 years, but this proportion increased less rapidly between 2 and 4 years. These children also had shorter daytime and total daily sleep duration at 2 years, but these levels decreased marginally less rapidly between 2 and 4 years. Based on existing studies (Acebo et al., 2005; Tétreault et al., 2019), it is expected that between ages 2 and 4 children show decreases in daytime, total, and nighttime sleep duration, and increases in sleep efficiency and proportion of nighttime sleep. Therefore, the findings can be interpreted as suggesting that children who were exposed to more paternal mind-mindedness at 18 months showed, at the age of 2, sleep patterns that were already approaching the patterns expected toward the end of the preschool period, namely shorter duration and greater consolidation into the night. However, their sleep also progressed less markedly thereafter (between 2 and 4 years). Hence, in early preschool years children of more mind-minded fathers seemed to be developmentally ahead of their peers regarding maturation of sleep patterns, but their peers caught up with them by the end of the preschool period. Consistent with this, additional analyses showed that the differences in sleep (daytime and total duration, proportion of nighttime sleep) between children exposed to more and less paternal mind-mindedness were no longer significant at 3 and 4 years. This suggests that any effects of mind-mindedness seem to fade, likely because other social and biological factors increasingly come into play in affecting preschoolers' sleep maturation. In fact, maturation itself may also decelerate among these children: children who already, at 2 years, are nearing the sleep outcomes expected later in the preschool period arguably have less room to change between ages 2 and 4. These children, once they have reached or approach expected sleep maturation outcomes, can move on to other developmental tasks – psychophysiological or other. We now turn to potential mechanisms by which paternal mind-mindedness may promote earlier maturation of sleep-wake patterns.

Paternal mind-mindedness and child sleep

Overall the results suggesting that paternal mind-mindedness is predictive of sleep developments are consistent with existing research that has consistently documented a link between parents' mind-mindedness and a range of developmental outcomes (Meins, Centifanti, Fernyhough, & Fishburn, 2013; Meins, Fernyhough, Arnott, Leekam, & de Rosnay, 2013; see McMahon & Bernier, 2017 for a review). It has been proposed that mind-related comments are one way in which caregivers act as external regulators of their child's affect and behavior (Fernyhough, 2008; McMahon & Bernier, 2017), gradually facilitating self-regulation and thus, possibly, sleep regulation. More precisely, the relation between mind-mindedness and sleep developments could be explained by emotional and psychophysiological regulatory pathways.

Emotion regulation. One way in which mind-mindedness may facilitate emotion regulation, which in turn may contribute to the orderly maturation of sleep-wake cycles, is by promoting a secure attachment bond with the parent. It has frequently been shown that children whose mother or father displays greater mind-mindedness are likely develop a more secure attachment relationship with that parent (see Zeegers et al., 2017 for a meta-analysis). The majority of relevant studies focused on maternal mind-mindedness and mother–child attachment security; however, Lundy (2003) reported that more frequent use by fathers of appropriate mind-related comments during interactions with their 6-month-old infant was associated with higher subsequent father-infant attachment security around 13 months of age. More recently, Miller et al. (2019) found that fathers' appropriate mind-related comments at 7 months predicted child attachment security at 2 years of age. Thus, there is evidence including in father–child dyads that parental mind-mindedness may promote parent-child attachment security, a core facilitator of child emotion regulation (Boldt, Goffin, & Kochanska, 2020; Calkins, 2004). In turn, meta-analytic findings indicate the presence of a significant, small to moderate, association between attachment and different indicators of sleep in children (Simard, Chevalier, & Bédard, 2017). Hence, paternal mind-mindedness may promote a secure father–child attachment relationship and thus contribute to children's sleep maturation by supporting their capacity to self-regulate their emotions.

Mind-mindedness may also facilitate regulation of mental processes. Parents' explicit labelling of their young children's mental states allows children to discover their own internal experience via their parents' verbal scaffold (Fernyhough, 2008). With time, this process may gradually bring children to develop their own mentalization capacity, namely the ability to make sense of internal experience. In turn, mentalization capacity is proposed to be crucial to affect regulation (Slade, 2005). Like attachment security, regulation of mental process (or mentalization) may thus foster better emotion regulation, which would contribute to children's sleep maturation.

Psychophysiological regulation. While the emotion regulatory skills afforded by mentalizing capacities and secure attachment can likely explain some of the longitudinal links between paternal mind-mindedness and maturation of child sleep patterns, it is likely that other processes are also at play in these links, including psychophysiological factors. Recently, Zeegers et al. (2018) observed that mothers' and fathers' appropriate mind-related comments independently predicted infants' heart rate variability (HRV) at 12 months, an indicator of parasympathetic nervous system (PNS) functioning that is implicated in emotion regulation. Interestingly, PNS-related factors have been implicated in children's sleep. El-Sheikh and colleagues reported associations between different indices of children's PNS activity, including respiratory sinus arrhythmia and skin conductance level, and multiple indicators of sleep quality and duration among preschoolers (Elmore-Staton, El-Sheikh, Vaughn, & Arsiwalla, 2012) and school-aged children (El-Sheikh & Buckhalt, 2005; El-Sheikh, Erath, & Bagley, 2013; Erath & El-Sheikh, 2015). Thus, psychophysiological regulation involving notably the PNS may constitute a distinct pathway linking paternal mind-mindedness to child subsequent sleep maturation.

Greater maturity or interindividual differences in sleep needs? Thus far, we have interpreted the results pertaining to shorter daytime and total sleep duration and increased proportion of nighttime sleep at age 2 as indicating more mature sleep patterns in children of more mind-minded fathers – in line with documented trends in preschool sleep developments. And indeed, there are processes by which parental mind-mindedness may favor sleep maturation as described above. Yet, a different take on the results, at least those pertaining to shorter daytime and total sleep duration, is that children exposed to more paternal mind-mindedness have lower sleep needs compared to their peers, and thus they sleep less at age 2. This hypothesis seems relatively improbable however, as it appears difficult to explain how paternal mind-mindedness would lead children to need less sleep. Furthermore, it is generally accepted that intrinsic sleep needs are largely biologically-driven (see e.g., Jenni, Molinari, Caflisch, & Largo, 2007) – making the hypothesis of a basic association between paternal mind-mindedness and lesser sleep needs in children somewhat unlikely. In fact, the association between higher mind-mindedness and higher proportion of nighttime sleep (a clear indicator of sleep maturation in early childhood) is in line with the hypothesis of greater sleep maturity. Finally, if the links observed here were due to individual differences in sleep needs, children of mind-minded fathers would be expected to sleep less overall, including at night. Yet, mind-mindedness was associated with shorter total and daytime sleep, not with nighttime sleep. Overall, the results observed here appear more likely to be due to more advanced sleep maturation among children of more mind-minded fathers; however, we cannot exclude the possibility that these children need less sleep during the day although not at night.

Father–child interactions

Some trend-level results were found with the general quality of father–child interactions: higher quality of father–child interactions was marginally predictive of shorter nighttime sleep duration at age 2 and slower subsequent annual decrease. As results were found on a single sleep variable and were marginally significant, the results with father–child interactions can be considered mostly inconclusive. This appears unlikely to be attributable to methodological factors, given that overall quality of interactions was measured at the same age and in fact based on the same free-play sequence as mind-mindedness, with equivalent reliability. In addition, the MRO scale used here to measure overall quality of interactions has been used frequently and shown to be a robust predictor of child outcomes (e.g., Kochanska, Forman, Aksan, & Dunbar, 2005; Kochanska & Murray, 2000) including with father–child dyads (e.g., Kochanska et al., 2008). Hence, the largely inconclusive results observed here appear to indicate that overall quality of father–child interactions may be less relevant than paternal mind-mindedness for preschool sleep developments. This may be because overall quality, as assessed here, fails to capture elements of father–child relationships that could support the development of children's emotional and psychophysiological regulatory skills that are postulated to account for the associations between father–child relationships and subsequent sleep developments. As one example, the presence of conflict or frustration in the father–child free play would automatically lead to lower MRO scores. In contrast, child frustration may actually lead to a higher mind-mindedness score if it is properly handled by the father, namely by labelling and validating the child's presumed mental state (e.g., "You are upset with me because I interrupted your play"). In turn, such verbal scaffolding of affect is likely to support children's self-regulatory capacities and thus promote their sleep in the long run.

It should however be noted that Bordeleau et al. (2012) found that the quality of father–child play interactions at 18 months, assessed with the MRO, was positively associated with sleep consolidation at ages 3 and 4, as reported by mothers using a sleep diary. Although important methodological distinctions may explain this difference in results (Bordeleau et al. studied sleep at specific ages rather than development across time, using a subjective measure), these prior results suggest that overall quality of father–child interactions during play has relevance for child sleep, and should continue to be studied in relation to developmental changes in sleep.

Paternal involvement

In the current study, no association was found between paternal involvement and the initial status or slope of any sleep variable. This is incongruent with other studies that found such relations (Bernier, Tétreault, Bélanger, & Carrier, 2017; Millikovsky-Ayalon et al., 2015; Tikotsky et al., 2011; 2015), however again with sleep at specific child ages (rather than development across a period of time). Moreover, in the studies by Millikovsky-Ayalon et al. and Tikotsky et al., paternal involvement was measured using a questionnaire assessing the involvement of fathers *relative* to mothers through specific concrete questions answered by both parents (e.g., "*Who usually feeds the infant"? 1 mother only; 4 mother and father equally; 7 father only*). This assessment approach likely diminishes the possibility that biases inherent to misperceptions or social desirability create inflated ratings of paternal involvement. Conversely, the measure used in the current study may be subject to such biases. In sum, it appears that paternal involvement can indeed be a potential predictor of children's sleep (at least sleep at specific ages) but, perhaps in part for methodological reasons, this relation was not detected in the current study.

Nighttime sleep and sleep efficiency

Significant results with paternal behaviors were found only for sleep variables that involve daytime sleep, and not with variables that focus exclusively on nighttime sleep (i.e., nighttime sleep duration and sleep efficiency). With regard to nighttime sleep duration, in the previous study by our team describing sleep developmental trajectories (Tétreault et al., 2019), the decrease found in nighttime sleep across the preschool period was not significant and the annual rate of change was less marked than for the other sleep variables. Moreover, although some cross-sectional studies suggested a small decrease of nighttime sleep duration during the preschool period (Acebo et al., 2005; Ward, Gay, Anders, Alkon, & Lee, 2008), it is generally accepted that nighttime sleep duration remains relatively stable across the preschool years (see Mindell & Owens, 2015). It was therefore not surprising that this variable's growth curve parameters were not predicted by paternal behavior, especially with a small sample as in the current study. However, the lack of results with sleep efficiency was unexpected as age-related increases in sleep efficiency are well documented at preschool age, including on this sample (Tétreault et al., 2019). Increased sleep efficiency therefore represents, like decreased daytime sleep and increased consolidation of sleep during the night, an expected development during the preschool period. The lack of significant results observed here could be meaningful, suggesting that the aspects of father–child relationships assessed here are not associated with developments in sleep efficiency during preschool years. One potential explanation, which however requires further research, is that sleep efficiency may be more endogenous and less influenced by environmental factors than sleep duration or distribution. This would be consistent with other studies that found, albeit with school-aged children, significant associations between parent-child relationships and sleep duration, but not sleep efficiency (Cimon-Paquet, Tétreault, & Bernier, 2019; Keller & El-Sheikh, 2011). However, the absence of statistically significant findings pertaining to sleep efficiency could also be explained by methodological reasons, as actigraphy is less accurate in detecting wake episodes (in comparison with sleep episodes) and thus in estimating sleep efficiency (Meltzer et al., 2016). In the current study a low sensitivity threshold was used in order to increase the precision of actigraphic data, but this is a less than perfect solution. Another potential explanation resides in the fact that at 2 years already, average sleep efficiency was above 90% in the current sample. Although the increase in sleep efficiency between ages 2 and 4 was statistically significant (Tétreault et al., 2019), the actual magnitude of this change may not have been sufficient to be predicted by father–child factors, given the already high starting point.

Limitations

It is important to mention several limitations of the current study. First, the generalizability of the results is limited by the use of a normative community sample. Also, as is common with studies that assess young children's sleep objectively (e.g., Berger, Miller, Seifer, Cares, & LeBourgeois, 2012; Scher, Hall, Zaidman-Zait, & Weinberg, 2010; Vaughn et al., 2011), the sample size was modest. Yet, the use of an MLM framework allowed us to handle this issue, given its documented capacity to yield reliable estimates with small samples. Burchinal et al. (2006) suggested that groups with as few as 30–50 participants are sufficient for reliable modeling, and simulation studies confirm that only samples of 50 participants or fewer can result in biased estimates in MLM (Maas & Hox, 2005). Another limitation is that a maximum of three nights of actigraphy was available. While this is relatively common when using actigraphy among young children (e.g., Scher et al., 2010; So, Buckley, Adamson, & Horne, 2005; Ward et al., 2008), it is recommended to use five days or more (Acebo et al., 1999). It also needs to be recognized that some predictions, albeit statistically significant, were quite modest, for instance mind-mindedness predicting a 0.24% slower annual increase in proportion of nighttime sleep.

Other limitations concern the father–child relationship measures. First, paternal involvement was self-reported in absolute terms and not relative to maternal involvement, which may have contributed, as explained above, to the lack of results with this predictor. Next, it would have been optimal to control for mothers' parallel behaviors at the same time points, in order to determine the unique contribution of father–child relationships beyond mother–child relationships. Such parallel assessments were not available at the targeted child ages. Finally, paternal behavior around bedtime and during the night was not assessed, yet previous studies have shown the relevance of these behaviors for child sleep (e.g., Mindell, Sadeh, Kohyama, & How, 2010; Philbrook & Teti, 2016).

Conclusion

Overall, the results of this study suggest that children who are exposed to more paternal mind-mindedness may reach more mature sleep patterns (i.e., increased nighttime sleep proportion and decreased daytime and total sleep duration) earlier in development. One open scientific question pertains to whether such earlier maturation of sleep wake-cycles is developmentally optimal, or whether slower, more gradual progression would be more beneficial. The former appears more likely, given that parental mind-mindedness is a well documented predictor of several positive socio-emotional, cognitive, psychophysiological, and neural outcomes in children (Dégeilh, Bernier, Leblanc, Daneault, & Beauchamp, 2018; McMahon & Bernier, 2017; Zeegers et al., 2018). Consequently, it would be unexpected that paternal mind-mindedness would predict poorer sleep outcomes. Still, the fact remains that research has yet to determine whether faster maturation of sleep-wake cycles in preschool years is beneficial. Investigating this question appears like an exciting direction for future research.

References

Acebo, C., Sadeh, A., Seifer, R., Tzischinsky, O., Hafer, A., & Carskadon, M. (2005). Sleep/wake patterns derived from activity monitoring and maternal report for healthy 1- to 5- year-old children. *Sleep, 28,* 1568-1577. doi:10.1093/sleep/28.12.1568

Acebo, C., Sadeh, A., Seifer, R., Tzischinsky, O., Wolfson, A. R., Hafer, A., & Carskadon, M. A. (1999). Estimating sleep patterns with activity monitoring in children and adolescents: How many nights are necessary for reliable measures? *Sleep, 22,* 95-103. doi:10.1093/sleep/22.1.95

Aksan, N., Kochanska, G., & Ortmann, M. R. (2006). Mutually responsive orientation between parents and their young children: Toward methodological advances in the science of relationships. *Developmental Psychology, 42,* 833-848. doi:10.1037/0012-1649.42.5.833

Bélanger, M. È., Bernier, A., Paquet, J., Simard, V., & Carrier, J. (2013). Validating actigraphy as a measure of sleep for preschool children. *Journal of Clinical Sleep Medicine, 9*, 701-706. doi:10.5664/jcsm.2844

Bell, B. G., & Belsky, J. (2008). Parents, parenting, and children's sleep problems: Exploring reciprocal effects. *British Journal of Developmental Psychology*, *26*, 579-593. doi:10.1348/026151008X285651

Berger, R. H., Miller, A. L., Seifer, R., Cares, S. R., & LeBourgeois, M. K. (2012). Acute sleep restriction effects on emotion responses in 30-to 36-month-old children. *Journal of Sleep Research, 21*, 235-246. doi:10.1111/j.1365-2869.2011.00962.x

Bernier, A., Bélanger, M.-È., & Tétreault, É. (2019). The hand that rocks the cradle: The family and parenting context of children's sleep. In B. H. Fiese, M. Celano, K. Deater-Deckard, E. N. Jouriles, & M. A. Whisman (Eds.), *APA handbook of contemporary family psychology: Applications and broad impact of family psychology* (pp. 137–151). American Psychological Association. doi:10.1037/0000100-009

Bernier, A., Tétreault, É., Bélanger, M. È., & Carrier, J. (2017). Paternal involvement and child sleep: A look beyond infancy. *International Journal of Behavioral Development*, *41,* 714-722. doi:10.1177/0165025416667851

Boldt, L. J., Goffin, K. C., & Kochanska, G. (2020). The significance of early parent-child attachment for emerging regulation: A longitudinal investigation of processes and mechanisms from toddler age to preadolescence. *Developmental Psychology*, *56*, 431-443. doi:10.1037/dev0000862

Bordeleau, S., Bernier, A., & Carrier, J. (2012). Longitudinal associations between the quality of parent−child interactions and children's sleep at preschool age. *Journal of Family Psychology*, *26*, 254-262. doi:10.1037/a0027366

Burchinal, M. R., Nelson, L., & Poe, M. (2006). IV. Growth curve analysis: An introduction to various methods for analyzing longitudinal data. *Monographs of the Society for Research in Child Development, 71*, 65-87. doi:10.1111/j.1540-5834.2006.00405.x

Cabrera, N. J., & Roggman, L. (2017). Father play: Is it special? *Infant Mental Health Journal, 38*, 706-708. doi:10.1002/imhj.21680

Cabrera, N., Tamis-LeMonda, C. S., Bradley, R. H., Hofferth, S., & Lamb, M. E. (2000). Fatherhood in the twenty-first century. *Child Development*, *71*, 127-136. doi:10.1111/1467-8624.00126

Calkins, S. D. (2004). Early attachment processes and the development of self regulation. In R. F. Baumeister & K. D. Vohs (Eds.), *Handbook of Self Regulation: Research, Theory and Applications* (pp. 324–339). New York: Guilford Press.

Calkins, S. D., & Hill, A. (2007). Caregiver influences on emerging emotion regulation. In J. J. Gross (Ed.), *Handbook of emotion regulation* (pp. 229-248). New York: Guilford Press.

Cimon-Paquet, C., Tétreault, É., & Bernier, A. (2019). Early parent-child relationships and child sleep at school age. *Journal of Applied Developmental Psychology, 64,* 101057. doi:10.1016 /j.appdev.2019.101057

Dahl, R. E., & El-Sheikh, M. (2007). Considering sleep in a family context: Introduction to the special issue. *Journal of Family Psychology, 21,* 1–3. doi:10.1037/0893-3200.21.1.1

Dégeilh, F., Bernier, A., Leblanc, É., Daneault, V., & Beauchamp, M. H. (2018). Quality of maternal behaviour during infancy predicts functional connectivity between default mode network and salience network 9 years later. *Developmental Cognitive Neuroscience*, *34*, 53-62. doi:10.1016/j.dcn.2018.06.003

De Wolff, M. S., & Van Ijzendoorn, M. H. (1997). Sensitivity and attachment: A meta-analysis on parental antecedents of infant attachment. *Child Development*, *68*, 571-591. doi:10.1111/j. 1467-8624.1997.tb04218.x

Dubois-Comtois, K., Pennestri, M. H., Bernier, A., Cyr, C., & Godbout, R. (2019). Family environment and preschoolers' sleep: The complementary role of both parents. *Sleep Medicine*, *58*, 114-122. doi:10.1016/j.sleep.2019.03.002

Elmore-Staton, L., El-Sheikh, M., Vaughn, B., & Arsiwalla, D. D. (2012). Preschoolers' daytime respiratory sinus arrhythmia and nighttime sleep. *Physiology & Behavior*, *107*, 414-417. doi:10.1016/j.physbeh.2012.07.005

El-Sheikh, M., & Buckhalt, J. A. (2015). Moving sleep and child development research forward: Priorities and recommendations from the SRCD-sponsored forum on sleep and child development. *Monographs of the Society for Research in Child Development*, *80*, 15-32. doi:10.1111/mono.12142

El-Sheikh, M., Erath, S. A., & Bagley, E. J. (2013). Parasympathetic nervous system activity and children's sleep. *Journal of Sleep Research*, *22*, 282-288. doi:10.1111/jsr.12019

El-Sheikh, M., & Kelly, R. J. (2017). Family functioning and children's sleep. *Child Development Perspectives, 11*, 264-269. doi:10.1111/cdep.12243

Erath, S., & El-Sheikh, M. (2015). Linking bioregulatory systems: Reciprocal autonomic activation predicts sleep over 1 year in middle childhood. *Developmental Psychobiology*, *57*, 17-24. doi:10.1002/dev.21246

Fernyhough, C. (2008). Getting Vygotskian about theory of mind: Mediation, dialogue, and the development of social understanding. *Developmental Review*, *28*, 225-262. doi:10.1016/j.dr. 2007.03.001

Goodlin-Jones, B. L., Burnham, M. M., Gaylor, E. E., & Anders, T. F. (2001). Night waking, sleep-wake organization, and self-soothing in the first year of life. *Journal of Developmental & Behavioral Pediatrics, 22*, 226–233. doi:10.1097/00004703-200108000-00003

Halpern, L. F., Anders, T. F., Coll, C. G., & Hua, J. (1994). Infant temperament: Is there a relation to sleep-wake states and maternal nighttime behavior? *Infant Behavior and Development*, *17,* 255–263. doi:10.1016/0163-6383(94)90004-3

Jenni, O. G., Molinari, L., Caflisch, J. A., & Largo, R. H. (2007). Sleep duration from ages 1 to 10 years: Variability and stability in comparison with growth. *Pediatrics, 120*, e769-e776. doi:10.1542/peds.2006-3300

Keller, P. S. (2011). Sleep and attachment. In M. El-Sheikh (Ed.), *Sleep and development: Familial and socio-cultural considerations* (pp. 49-78). New York: Oxford University Press.

Keller, P. S., & El-Sheikh, M. (2011). Children’s emotional security and sleep: Longitudinal relations and directions of effects. *Journal of Child Psychology & Psychiatry, 52*, 64-71. doi:10.1111/j.1469-7610.2010.02263.x

Kocevska, D., Muetzel, R. L., Luik, A.I., Luijk, M.P., Jaddoe, V. W., Verhulst, F.C., White, T., & Tiemeier, H. (2017). The developmental course of sleep disturbances across childhood relates to brain morphology at age 7: The generation R study. *Sleep*, *40*, zsw022. doi:10.1093 /sleep /zsw022.

Kochanska, G., Aksan, N., Prisco, T. R., & Adams, E. E. (2008). Mother-child and father-child mutually responsive orientation in the first two years and children's outcomes at preschool age: Mechanisms of influence. *Child Development*, *79*, 30-44. doi:10.1111/j.1467-8624.2007.01109.x

Kochanska, G., Forman, D. R., Aksan, N., & Dunbar, S. B. (2005). Pathways to conscience: Early mother–child mutually responsive orientation and children's moral emotion, conduct, and cognition. *Journal of Child Psychology and Psychiatry*, *46*, 19-34. doi:10.1111/j.1469-7610.2004.00348.x

Kochanska, G., & Murray, K. T. (2000). Mother–child mutually responsive orientation and conscience development: From toddler to early school age. *Child Development*, *71*, 417-431. doi:10.1111/1467-8624.00154

Lalonde, G., Bernier, A., Beaudoin, C., Gravel, J., & Beauchamp, M. H. (2016). Investigating social functioning after early mild TBI: The quality of parent–child interactions. *Journal of Neuropsychology*, *12*, 1-22. doi:10.1111/jnp.12104

Lundy, B. L. (2003). Father–and mother–infant face-to-face interactions: Differences in mind-related comments and infant attachment? *Infant Behavior and Development*, *26*, 200-212. doi:10.1016/S0163-6383(03)00017-1

Lundy, B. L. (2013). Paternal and maternal mind-mindedness and preschoolers' theory of mind: The mediating role of interactional attunement. *Social Development*, *22*, 58-74. doi:10.1111/ sode.12009

Maas, C. J., & Hox, J. J. (2005). Sufficient sample sizes for multilevel modeling. *Methodology, 1,* 86-92. doi:10.1027/1614-2241.1.3.86

Magee, C. A., Gordon, R., & Caputi, P. (2014). Distinct developmental trends in sleep duration during early childhood. *Pediatrics, 133*, e1561-e1567. doi:10.1542/peds.2013-3806

McDaniel, B. T., & Teti, D. M. (2012). Coparenting quality during the first three months after birth: The role of infant sleep quality. *Journal of Family Psychology*, *26*, 886-895. doi:10.1037/a0030707

McMahon, C. A., & Bernier, A. (2017). Twenty years of research on parental mind-mindedness: Empirical findings, theoretical and methodological challenges, and new directions. *Developmental Review*, *46*, 54-80. doi:10.1016/j.dr.2017.07.001

Meins, E., Centifanti, L. C. M., Fernyhough, C., & Fishburn, S. (2013). Maternal mind-mindedness and children's behavioral difficulties: Mitigating the impact of low socioeconomic status. *Journal of Abnormal Child Psychology*, *41*, 543-553. doi: 10.1007/s10802-012-9699-3

Meins, E., Fernyhough, C., Arnott, B., Leekam, S. R., & de Rosnay, M. (2013). Mind-mindedness and theory of mind: Mediating roles of language and perspectival symbolic play. *Child Development*, *84*, 1777-1790. doi:10.1111/cdev.12061

Meins, E., Fernyhough, C., Fradley, E., & Tuckey, M. (2001). Rethinking maternal sensitivity: Mothers' comments on infants' mental processes predict security of attachment at 12 months. *The Journal of Child Psychology and Psychiatry and Allied Disciplines*, *42*, 637-648. doi:10.1017/S0021963001007302

Meltzer, L. J., Montgomery-Downs, H. E., Insana, S. P., & Walsh, C. M. (2012). Use of actigraphy for assessment in pediatric sleep research. *Sleep Medicine Reviews*, *16*, 463-475. doi:10.1016/j.smrv.2011.10.002

Meltzer, L. J., Wong, P., Biggs, S. N., Traylor, J., Kim, J. Y., Bhattacharjee, R., ... & Marcus, C. L. (2016). Validation of actigraphy in middle childhood. *Sleep*, *39*, 1219-1224. doi:10.5665/ sleep.5836

Miller, J. E., Kim, S., Boldt, L. J., Goffin, K. C., & Kochanska, G. (2019). Long-term sequelae of mothers' and fathers' mind-mindedness in infancy: A developmental path to children's attachment at age 10. *Developmental Psychology, 55*, 675-686. doi:10.1037/dev0000660

Millikovsky-Ayalon, M., Atzaba-Poria, N., & Meiri, G. (2015). The role of the father in child sleep disturbance: Child, parent, and parent-child relationship. *Infant Mental Health Journal, 36*, 114-127. doi:10.1002/imhj.21491

Mindell, J. A., & Owens, J. A. (2015). *A clinical guide to pediatric sleep: Diagnosis and management of sleep problems* (3rd ed.). Philadelphia, PA: Lippincott, Williams, & Wilkins.

Mindell, J. A., Sadeh, A., Kohyama, J., & How, T. H. (2010). Parental behaviors and sleep outcomes in infants and toddlers: A cross-cultural comparison. *Sleep Medicine*, *11*, 393-399. doi:10.1016/j.sleep.2009.11.011

NICHD Early Child Care Research Network (2000). Factors associated with fathers' caregiving activities and sensitivity with young children. *Journal of Family Psychology, 14*, 200-219. doi: 10.1037/0893-3200.14.2.200

Paquette, D., Bolté, C., Turcotte, G., Dubeau, D., & Bouchard, C. (2000). A new typology of fathering: Defining and associated variables. *Infant & Child Development*, *9*, 213-230. doi:10.1002/1522-7219

Philbrook, L.E. & Teti, D.M. (2016). Bidirectional associations between bedtime parenting and infant sleep: Parenting quality, parenting practices, and their interaction. *Journal of Family Psychology, 30,* 431–441. doi:10.1037/fam0000198

Plancoulaine, S., Reynaud, E., Forhan, A., Lioret, S., Heude, B., Charles, M. A., ... & Dargent-Molina, P. (2018). Night sleep duration trajectories and associated factors among preschool children from the EDEN cohort. *Sleep Medicine*, *48*, 194-201. doi:10.1016/j.sleep.2018.03.030

Rhoades, K. A., Leve, L. D., Harold, G. T., Mannering, A. M., Neiderhiser, J. M., Shaw, D. S., Natsuaki, M. N., & Reiss, D. (2012). Marital hostility and child sleep problems: Direct and indirect associations via hostile parenting. *Journal of Family Psychology, 26*, 488–498. doi: 10.1037/a0029164

Sadeh, A. (2015). Sleep assessment methods. *Monographs of the Society for Research in Child Development, 80*, 33-48. doi:10.1111/mono.12143

Sadeh, A., Flint-Ofir, E., Tirosh, T., & Tikotzky, L. (2007). Infant sleep and parental sleep-related cognitions. *Journal of Family Psychology*, *21*, 74-87. doi:10.1037/0893-3200.21.1.74

Sadeh, A., Lavie, P., Scher, A., Tirosh, E., & Epstein, R. (1991). Actigraphic home-monitoring sleep-disturbed and control infants and young children: A new method for pediatric assessment of sleep-wake patterns. *Pediatrics, 87,* 494-499. Retrieved from http://pediatrics.aappublications.org/content/pediatrics/87/4/494.full.pdf

Sadeh, A., Tikotzky, L., & Scher, A. (2010). Parenting and infant sleep. *Sleep Medicine Reviews*, *14*, 89-96. doi:10.1016/j.smrv.2009.05.003

Scher, A., Hall, W. A., Zaidman-Zait, A., & Weinberg, J. (2010). Sleep quality, cortisol levels, and behavioral regulation in toddlers. *Developmental Psychobiology, 52*, 44-53. doi:10 .1002/dev.20410

Schoppe-Sullivan, S. J., & Fagan, J. (2020). The evolution of fathering research in the 21st century: Persistent challenges, new directions. *Journal of Marriage and Family, 82,* 175-197. doi:10.1111/jomf.12645

Schore, A. N. (1996). The experience-dependent maturation of a regulatory system in the orbital prefrontal cortex and the origin of developmental psychopathology. *Development and Psychopathology, 8*, 59-87. doi:10.1017/S0954579400006970

Simard, V., Chevalier, V., & Bédard, M. M. (2017). Sleep and attachment in early childhood: A series of meta-analyses. *Attachment & Human Development*, *19*, 298-321. doi:10.1080/14616734.2017.1293703

Sinai, D., & Tikotzky, L. (2012). Infant sleep, parental sleep and parenting stress in families of mothers on maternity leave and in families of working mothers. *Infant Behavior & Development, 35*, 179–186. doi:10.1016/j.infbeh.2012.01.006

Singer, J. D., & Willett, J. B. (2003). *Applied longitudinal data analysis: Modeling change and event occurrence.* New York, NY: Oxford University Press.

Sitnick, S. L., Goodlin-Jones, B. L., & Anders, T. F. (2008). The use of actigraphy to study sleep disorders in preschoolers: some concerns about detection of nighttime awakenings. *Sleep*, *31*, 395-401. Retrieved from http://www.ncbi.nlm.nih.gov /pmc/articles/PMC2276752/

Slade, A. (2005). Parental reflective functioning: An introduction. *Attachment and Human Development*, *7*, 269-281. doi:10.1080/14616730500245906

So, K., Buckley, P. A. T., Adamson, T. M., & Horne, R. S. (2005). Actigraphy correctly predicts sleep behavior in infants who are younger than six months, when compared with polysomnography. *Pediatric Research, 58*, 761-765. doi:10.1203/01.PDR.0000180568 .97221.56

Sung, M., Adamson, T. M., & Horne, R. S. (2009). Validation of actigraphy for determining sleep and wake in preterm infants. *Acta Paediatrica, 98*, 52-57. doi:10.1111/j.1651-2227.2008 f.01002.x

Tétreault, É., Bernier, A., Matte-Gagné, C., & Carrier, J. (2019). Normative developmental trajectories of actigraphic sleep variables during the preschool period: A three-wave longitudinal study. *Developmental Psychobiology*, *61*, 141-153. doi:10.1002/dev.21805

Tikotzky, L., Sadeh, A., & Glickman-Gavrieli, T. (2011). Infant sleep and paternal involvement in infant caregiving during the first 6 months of life. *Journal of Pediatric Psychology*, *36*, 36-46. doi:10.1093/jpepsy/jsq036

Tikotzky, L., Sadeh, A., Volkovich, E., Manber, R., Meiri, G., & Shahar, G. (2015). Infant sleep development from 3 to 6 months postpartum: Links with maternal sleep and paternal involvement. *Monographs of the Society for Research in Child Development*, *80*, 107-124. doi:10.1111/mono.12147

Touchette, E., Côté, S. M., Petit, D., Liu, X., Boivin, M., Falissard, B., ... Montplaisir, J. Y. (2009). Short nighttime sleep-duration and hyperactivity trajectories in early childhood. *Pediatrics, 124*, 985-993. doi:10.1542/peds.2008-2005

Touchette, E., Petit, D., Tremblay, R. E., Boivin, M., Falissard, B., Genolini, C., & Montplaisir, J.Y. (2008). Associations between sleep duration patterns and overweight/obesity at age 6. *Sleep, 31*, 1507-1514. doi:10.1093/sleep/31.11.1507

Vaughn, B., El-Sheikh, M., Shin, N., Elmore-Staton, L., Krzysik, L., & Monteiro, L. (2011). Attachment representations, sleep quality and adaptive functioning in preschool age children. *Attachment and Human Development, 13*, 525-540. doi:10.1080/14616734.2011.608984

Volkovich, E., Bar-Kalifa, E., Meiri, G., & Tikotzky, L. (2018). Mother–infant sleep patterns and parental functioning of room-sharing and solitary-sleeping families: A longitudinal study from 3 to 18 months. *Sleep, 41*, zsx207. doi:10.1093/sleep/zsx207

Volling, B. L., & Cabrera, N. J. (2019). Advancing research and measurement on fathering and child development: I. Advancing research and measurement on fathering and child development: Introducing the issues and a conceptual framework. *Monographs of the Society for Research in Child Development, 84*, 7–17. doi:10.1111/mono.12404

Ward, T. M., Gay, C., Anders, T. F., Alkon, A., & Lee, K. A. (2008). Sleep and napping patterns in 3-to-5-year old children attending full-day childcare centers. *Journal of Pediatric Psychology, 33,* 666-672. doi:10.1093/jpepsy/jsm102

Weinraub, M., Bender, R. H., Friedman, S. L., Susman, E. J., Knoke, B., Bradley, R., ... Williams, J. (2012). Patterns of developmental change in infants' nighttime sleep awakenings from 6 through 36 months of age. *Developmental Psychology, 48*, 1511-1528. doi:10.1037/a0027680

Williamson, A. A., Mindell, J. A., Hiscock, H., & Quach, J. (2019). Sleep Problem Trajectories and Cumulative Socio-Ecological Risks: Birth to School-Age. *The Journal of Pediatrics*, *215*, 229-237. doi:10.1016/j.jpeds.2019.07.055

Zeegers, M. A., Colonnesi, C., Stams, G. J. J., & Meins, E. (2017). Mind matters: A meta-analysis on parental mentalization and sensitivity as predictors of infant–parent attachment. *Psychological Bulletin*, *143*, 1245-1272. doi:10.1037/bul0000114

Zeegers, M. A., de Vente, W., Nikolić, M., Majdandžić, M., Bögels, S. M., & Colonnesi, C. (2018). Mothers' and fathers' mind-mindedness influences physiological emotion regulation of infants across the first year of life. *Developmental Science*, *21*, e12689. doi:10.1111/desc. 12689

Table 1

Descriptive statistics for the main study variables

	Mean	Standard deviation
Paternal mind-mindedness	15.01	10.69
Father-child interactions	3.08	0.87
Paternal involvement	28.80	2.88
Daytime sleep duration (hours)		
Intercept	2.30	0.15
Slope	-0.35	0.10
Total daily sleep duration (hours)		
Intercept	11.82	0.19
Slope	-0.50	0.14
Proportion of nighttime sleep (%)		
Intercept	80.74	1.27
Slope	2.57	0.88
Nighttime sleep duration (hours)		
Intercept	9.50	0.14
Slope	-0.12	0.10
Sleep efficiency (%)		
Intercept	91.31	0.87
Slope	1.98	0.64

Note. Values for sleep variables are averages of the three days of data.

Table 2

Correlations among covariates and predictors

	2	3	4	5
1. Child sex	-.17	-.02	.03	-.46**
2. Family socioeconomic status	-----	.14	.05	.09
3. Paternal mind-mindedness		-----	.05	.13
4. Quality of father-child interactions			-----	-.13
5. Paternal involvement				-----

Note. Child sex is coded: 1 = boy; 2 = girl.
** $p < .01$

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	Daytime duration	Total daily sleep duration	Proportion of nighttime sleep	Nighttime duration	Sleep efficiency
d-					
s	-0.35*	-0.46*	0.25*	-0.14	-1.25
	(0.17)	(0.19)	(0.12)	(0.16)	(1.50)
nge	0.31^{t}	0.41^{t}	-0.24**	0.11	-0.07
	(0.19)	(0.22)	(0.09)	(0.13)	(1.23)
s	-0.12	-0.36	0.49	-0.35^{t}	-2.32
	(0.22)	(0.22)	(1.87)	(0.18)	(1.47)
nge	0.06	0.18	-0.15	0.22^{t}	1.08
	(0.13)	(0.18)	(1.12)	(0.12)	(1.21)
lvement					
s	0.04	0.12	-0.11	0.10	-0.26
	(0.14)	(0.21)	(1.15)	(0.17)	(1.14)
nge	-0.01	-0.01	-0.24	-0.02	0.39
	(0.10)	(0.23)	(0.86)	(0.11)	(1.05)

errors are within parentheses. Coefficients shown are those found while accounting for child sex and family socioeconomic ee predictors are tested in separate models. $^{t}p < .10$. $^{*}p < .05$. $^{**}p < .01$.

Conclusion

Le rôle essentiel du sommeil dans le développement de l'enfant est bien démontré dans la littérature (ex., Dewald et al., 2010; Dutil et al., 2018; Miller et al., 2015; Smithson et al., 2018; Williams et al., 2016), mais peu d'études ont étudié le développement normatif du sommeil chez l'enfant à l'aide de devis longitudinaux et de méthodes de mesure objectives (ex., actigraphie). Ainsi, il y a peu de connaissances au sujet des véritables patrons de développement normatif que suit le sommeil au cours de l'enfance et des facteurs pouvant influencer ces développements. De plus, peu d'études se sont penchées sur les méthodes de cotation des données d'actigraphie. L'objectif général de la thèse consistait donc à accroitre les connaissances empiriques sur le sommeil des enfants mesuré par actigraphie en examinant la méthode de cotation des données et en se penchant sur des questions développementales et familiales, soit le développement normatif du sommeil à travers l'âge préscolaire et le rôle potentiellement prédicteur de la relation père-enfant dans ce développement.

Dans cette conclusion, les résultats des trois articles seront discutés. Des pistes de réflexion et de recherches futures ainsi que les potentielles applications cliniques et les limites de la thèse seront ensuite abordées.

La cotation des données d'actigraphie

L'actigraphie est une méthode reconnue comme valide et pratique pour mesurer le sommeil chez les enfants (ex., Meltzer et al., 2012; Sadeh, 2015). Malgré l'augmentation de son utilisation dans les dernières décennies, il y a toujours peu de lignes directrices publiées pouvant guider les chercheurs dans la collecte et l'analyse des données d'actigraphie (Meltzer & Westin, 2011; Schoch et al., 2020). L'article 1 visait à aborder une question, très peu étudiée jusqu'ici, sur la méthode de cotation des données d'actigraphie. Le but était de déterminer s'il serait possible dans les études d'utiliser une portion de données d'actigraphie qui ne seraient pas, contrairement à la pratique courante, corroborées par un agenda de sommeil complété par les parents. Pour ce faire, une comparaison a été effectuée entre des données d'actigraphie analysées avec et sans agenda de sommeil. Les méthodes d'analyses employées ont permis d'étudier la concordance entre les deux méthodes de cotation à un niveau de groupe, mais aussi à un niveau individuel (enfant par enfant).

L'approche de groupe a démontré une forte concordance entre les deux méthodes de cotation et a montré que les enfants maintenaient le même rang (de façon presqu'identique) dans le groupe dans les deux conditions. L'approche individuelle (à l'aide des analyses Bland-Altman) a montré par ailleurs que les deux conditions ne pouvaient pas être considérées comme étant interchangeables, bien que les différences entre les deux étaient plutôt petites. Bref, les résultats suggèrent que les deux méthodes de cotation (avec et sans agenda de sommeil) mènent à des résultats similaires, pratiquement identiques à un niveau de groupe, mais pas interchangeables lorsque mesurées à un niveau intra-individuel. Ainsi, les études qui utilisent l'actigraphie pour mesurer les différences interindividuelles dans le sommeil des enfants (ce qui est le cas de la majorité des études) pourraient inclure sans problème des données d'actigraphie pour lesquelles des données d'agenda ne seraient pas disponibles. Cependant, pour les études qui viseraient à mesurer la durée exacte du sommeil ou des éveils chez un enfant (ex., études visant à établir des normes précises de sommeil), les différences obtenues avec l'approche individuelle, même si petites, pourraient justifier le fait de ne pas inclure les données d'actigraphie qui ne seraient pas corroborées par un agenda de sommeil.

Ainsi, selon les résultats de l'article 1, il semble préférable dans les études de continuer à demander aux parents de compléter un agenda de sommeil afin d'obtenir des informations importantes (ex., heure du coucher et du lever, potentiels artéfacts dans les données). Néanmoins, l'article permet de conclure qu'il est possible d'inclure au besoin une modeste portion de données d'actigraphie analysées sans agenda de sommeil et que la validité de ces données ne serait pas compromise. Il s'agit d'une alternative intéressante pour les chercheurs qui étudient le sommeil des enfants à l'aide de l'actigraphie, notamment parce que les échantillons dans ce type d'études sont en général de taille modeste et que le fait d'éliminer les nuits ou les participants pour lesquels l'agenda n'a pas été complété réduit encore davantage la quantité de données disponibles.

Le développement du sommeil au cours de la période préscolaire

Afin de pallier au manque d'études au sujet des patrons de développement dans le sommeil au cours de la période préscolaire, l'article 2 examinait les changements développementaux dans cinq indices de sommeil entre 2 et 4 ans. Pour ce faire, un devis longitudinal, des analyses statistiques de pointe et l'actigraphie en tant que mesure objective de sommeil ont été utilisés. Les analyses multiniveaux ont permis d'examiner le changement intra-individuel (comment le sommeil d'un enfant donné change d'âge en âge) ainsi que les différences interindividuelles (entre les enfants) dans les changements.

Pour commencer, toutes les variables de sommeil étudiées présentaient un développement linéaire à travers la période préscolaire, c'est-à-dire que chaque variable présentait une augmentation ou une diminution constante entre 2 et 4 ans. Les variables inhérentes à la durée de sommeil (durée de sommeil de jour, de nuit et totale sur 24 heures) présentaient une diminution linéaire, alors que les variables de pourcentage de sommeil durant la nuit et d'efficacité de sommeil présentaient une augmentation linéaire à travers la période préscolaire. De plus, la majorité de ces diminutions et augmentations à travers le temps étaient statistiquement significatives (à l'exception de la durée de sommeil de nuit), confirmant ainsi que plusieurs changements significatifs ont lieu en moyenne dans le sommeil de l'enfant entre 2 et 4 ans.

Une autre question qui a pu être examinée est à quel point les enfants diffèrent entre eux au niveau des changements observés dans le sommeil (différences interindividuelles). Le taux annuel de changement était relativement similaire pour tous les participants, ce qui suggère que les développements dans le sommeil à travers la période préscolaire sont assez uniformes parmi les enfants. Ceci pourrait notamment être associé au fait que les développements dans le sommeil à cette période seraient déterminés de façon prédominante par la maturation de processus biologiques qui survient généralement aux mêmes âges et à un rythme similaire pour une majorité d'enfants. Par ailleurs, pour quatre des cinq variables de sommeil étudiées on retrouvait une variance significative autour du niveau initial de sommeil à 2 ans. Donc, il semble que le sommeil se développe de façon plutôt similaire pour les enfants au cours de la période préscolaire, mais que les enfants présentent des différences significatives quant à leurs niveaux initiaux de sommeil à l'entrée dans cette période. En se basant sur la littérature, il est possible de croire que ces différences au début de la période préscolaire puissent être associées à des facteurs intrinsèques et des influences environnementales ayant lieu au cours des deux premières années de vie de l'enfant (voir Camerota et al., 2019, pour une revue des facteurs intrinsèques et extrinsèques pouvant influencer le sommeil des nourrissons). Au niveau des facteurs intrinsèques, certaines études ont démontré un lien entre le tempérament de l'enfant et son sommeil dans les deux premières années de vie (Halpern et al.,1994; Scher & Ascher, 2004; Weinraub et al., 2012). À ces mêmes âges, d'autres études ont trouvé des associations entre les variations individuelles au niveau de la réactivité et régulation physiologique, notamment des indices de la production de cortisol (Bright et al., 2014; Scher et al., 2010; Stalder et al., 2013) et d'arythmie sinusale respiratoire (Gueron-Sela et al., 2017) et le sommeil des enfants. Au niveau environnemental, les comportements parentaux et les interactions parent-enfant représenteraient les principaux facteurs associés au sommeil dans les deux premières années de vie (Camerota et al., 2019). Les pratiques parentales qui encouragent la dépendance envers la présence des parents autour du coucher et durant la nuit (p.ex. présence du parent à l'endormissement) ont été associées négativement au sommeil des nourrissons (Burnham et al., 2002; Goodlin-Jones et al., 2001; Mindell et al., 2010; Morrell & Steel, 2003), tandis que les routines (Mindell et al., 2009; 2015) et la disponibilité émotionnelle du parent (Philbrook & Teti, 2016; Teti et al., 2010) autour du coucher y ont été associées positivement. Enfin, la sensibilité parentale (Bordeleau et al., 2012; Priddis, 2009; Tétreault et al., 2017), l'attachement parent-enfant (Bélanger et al., 2015) et la qualité des interactions parent-enfants (Bordeleau et al, 2012) durant la journée ont été associés au sommeil des enfants dans les deux premières années de vie.

Finalement, il a été observé que le niveau initial (sommeil à 2 ans) et la pente (taux de changement annuel) des courbes de croissance de sommeil étaient statistiquement indépendants pour toutes les variables de sommeil à l'étude. Donc, le niveau initial de sommeil au début de la période préscolaire ne prédirait pas la façon dont le sommeil va se développer au cours de cette période. Ces résultats suggèrent que le statut initial au début d'une période développementale et le taux de changement au sein de cette période seraient deux façons distinctes de caractériser le sommeil des enfants. Il est ainsi possible de s'attendre à ce que chacun de ces paramètres soit associé à des prédicteurs différents et prédise des issues développementales différentes.

En somme, l'article 2 permet de fournir des points de repères quantitatifs quant aux développements attendus dans le sommeil des enfants au cours de la période préscolaire et permet de confirmer que des changements linéaires significatifs ont lieu au cours de cette période.

La relation père-enfant comme prédicteur du développement du sommeil à travers la période préscolaire

Après avoir démontré, par le biais de l'article 2, que des changements importants avaient lieu dans le sommeil au cours de la période préscolaire, il était intéressant de chercher à identifier des facteurs pouvant potentiellement prédire ces changements. L'article 3 visait à examiner si la relation père-enfant, à notre connaissance jamais étudiée jusqu'ici en lien avec les développements dans le sommeil de l'enfant, pouvait être un prédicteur des différences individuelles dans les patrons de développement du sommeil entre 2 et 4 ans. Plus spécifiquement, trois aspects de la relation père-enfant ont été examinés : l'orientation mentale paternelle, la qualité des interactions père-enfant et le niveau d'implication paternelle.

Les résultats n'ont démontré aucune association entre le degré d'implication paternelle et les paramètres de courbes de croissance de sommeil. La qualité des interactions père-enfant était associée à la trajectoire d'une seule variable de sommeil (la durée de sommeil de nuit), et de façon marginale. Par ailleurs, des résultats concluants ont été obtenus avec l'orientation mentale paternelle. Les enfants dont le père faisait plus de commentaires appropriés sur leurs états mentaux à 18 mois présentaient, à 2 ans, une plus grande proportion de sommeil durant la nuit ainsi qu'une plus courte durée de sommeil de jour et totale sur 24 heures. Par ailleurs, ces enfants présentaient par la suite des changements moins rapides sur ces variables de sommeil entre 2 et 4 ans. Considérant les études précédentes, et notamment l'article 2, qui montrent qu'il est attendu que la proportion de sommeil durant la nuit augmente et que la durée de sommeil de jour et totale diminue au cours de la période préscolaire, il est possible de conclure à partir de ces résultats que les enfants exposés à un plus haut niveau d'orientation mentale paternelle atteignent des patrons de sommeil plus matures plus tôt dans leur développement.

Intégration des articles de la thèse et avenues de recherche futures

Le sommeil des enfants se présente comme un sujet complexe, avec de multiples angles à considérer et qui nécessite d'accumuler beaucoup de connaissances empiriques, ce à quoi les articles de la thèse ont pu contribuer.

Un aspect de la recherche qui nécessiterait davantage d'attention concerne les questions méthodologiques associées à l'actigraphie. L'article 1 a permis de conclure que lorsque l'actigraphie est utilisée pour mesurer le sommeil de nuit auprès d'enfants d'âge scolaire issus de la population générale, il est possible d'inclure une portion de données d'actigraphie pour lesquelles il n'y a pas d'agenda disponible pour corroborer les données. Il serait cependant nécessaire de répliquer ce genre d'étude avec d'autres populations (ex., populations clinique, enfants d'âges différents), d'autres modèles d'actigraphe et des algorithmes différents pour l'analyse des données. De plus, le sommeil pédiatrique mesuré par actigraphie comporte plusieurs autres enjeux méthodologiques. Au niveau de l'enregistrement des données, les chercheurs doivent prendre des décisions notamment sur le modèle d'actigraphe à utiliser, les indications fournies aux participants quant à l'endroit où porter l'actigraphe, le mode de collection des données et la longueur des périodes d'enregistrement (niveau d'activité enregistré par 30, 60 secondes ou autres). Pour ce qui est de l'analyse des données, des choix se posent quant à l'algorithme utilisé et le seuil de sensibilité pour détecter les éveils ainsi que les règles de cotation pour déterminer les moments d'endormissement et de réveil et pour éliminer les périodes présentant possiblement des artefacts ou données invalides. Deux revues de littérature ont conclu au besoin de développer des pratiques standardisées quant à la collecte et la cotation des données d'actigraphie ainsi qu'à la façon dont ces aspects méthodologiques sont rapportés dans les études, soulignant qu'actuellement il y a beaucoup d'incohérence à cet effet (Meltzer et al., 2012; Schoch et al., 2020). Dans une large proportion d'articles, ces informations ne sont pas mentionnées, ce qui fait en sorte que les chercheurs et cliniciens ont peu de repères pour les guider dans l'utilisation de l'actigraphie. De plus, les données sont difficilement comparables entre les études vu un manque d'uniformité dans la façon dont elles sont collectées, analysées et rapportées (Meltzer et al., 2012; Schoch et al., 2020). Bref, des études supplémentaires apparaissent essentielles afin de mieux documenter et uniformiser les aspects méthodologiques associés à l'emploi de l'actigraphie pour mesurer le sommeil des enfants.

En ce qui concerne l'aspect développemental du sommeil, il est intéressant de mettre en commun les résultats de l'article 2 et 3. L'article 2 permettait de conclure que la majeure partie de la variance dans les développements des différents indices de sommeil était de nature intra-individuelle et que les différences interindividuelles quant au taux de changement annuel étaient non-significatives. Il est ainsi intéressant de constater que, dans l'article 3, l'orientation mentale paternelle parvient tout de même à prédire de façon marginale ou significative ces différences pour certaines variables de sommeil. La variance non-significative autour du taux de changement annuel ne signifierait donc pas une absence de différence entre les enfants, mais bien des différences qui ne sont pas assez marquées pour être statistiquement significatives. Il est possible de croire que ces différences pourraient devenir significatives au sein d'un plus grand échantillon (et donc avec une plus grande puissance statistique). Dans l'article 3, l'orientation mentale paternelle apparait aussi comme un prédicteur des niveaux initiaux de différentes variables de sommeil, ce qui est cohérent avec l'article 2 qui montrait effectivement des différences inter-individuelles significatives autour des niveaux initiaux. Aussi, l'article 2 permettait de conclure que le niveau initial et le taux de changement étaient deux paramètres indépendants des courbes de croissance de sommeil et donc que le niveau initial d'un indice de sommeil à l'entrée de la période préscolaire ne permettait pas de prédire le taux de changement subséquent au sein de cet indice. Dans l'article 3, un certain patron de relation entre le statut initial et le taux de changement semble émerger, montrant que les enfants exposés à davantage d'orientale mentale débutent la période préscolaire avec un niveau de maturité supérieur dans leurs patrons de sommeil, mais que cette maturation est ensuite plus lente entre 2 et 4 ans en comparaison avec leurs pairs. Des analyses supplémentaires ont d'ailleurs confirmé que les différences entre les enfants exposés à de plus hauts niveaux d'orientation mentale et leurs pairs n'étaient plus significatives à 3 et 4 ans. Ainsi, l'orientation mentale paternelle apparait comme un prédicteur important du niveau initial de sommeil au début de la période préscolaire, mais son effet semble ensuite se réduire avec le temps.

Aussi, comme très peu d'études ont porté sur le sujet jusqu'à présent, il parait important de chercher à identifier des facteurs intrinsèques (ex., tempérament; Bastien et al., 2020) et environnementaux qui pourraient prédire les différences individuelles dans les paramètres (statut initial et taux de changement) des courbes de croissance de sommeil à travers l'âge préscolaire. De plus, les futures recherches pourraient s'intéresser aux domaines de développement ou fonctionnement qui sont influencés par les trajectoires de sommeil à l'âge préscolaire, sachant que les trajectoires de sommeil à l'âge scolaire et à l'adolescence ont été associées avec divers domaines de fonctionnement (Bub et al., 2011; El-Sheikh et al., 2013; Fredriksen et al., 2004; Goodnight et al., 2007). D'ailleurs, deux études récentes de notre équipe ont démontré que les courbes de croissance de sommeil à l'âge préscolaire permettaient de prédire de meilleures fonctions exécutives (Bernier et al., sous presse) ainsi que de meilleures performances en lecture et en mathématiques (Bernier et al., 2020) à l'entrée de l'école primaire.

Applications cliniques

La présente thèse, et plus particulièrement l'article 2, permet de fournir des points de repère quant aux changements normatifs attendus dans le sommeil à l'âge préscolaire. De tels repères sont importants afin de permettre aux parents et aux professionnels d'identifier les enfants qui présentent un sommeil qui diverge des changements développementaux attendus ou qui présentent une détérioration au niveau de leur sommeil. La connaissance des développements normatifs attendus peut notamment permettre aux parents de savoir quand il devient indiqué de consulter un professionnel pour aborder le sommeil de leur enfant. Cela pourrait aussi permettre de diminuer les inquiétudes ou les questionnements des parents face aux changements qu'ils observent dans le sommeil de leur enfant et leur permettre d'adapter leurs réactions face à ces changements, notamment entretenir des attentes réalistes et instaurer des limites appropriées. Il est d'ailleurs reconnu qu'une difficulté à mettre des limites ainsi qu'un décalage entre les attentes des parents face au sommeil de l'enfant et les développements normatifs attendus peuvent représenter des facteurs contribuant à précipiter ou maintenir les difficultés de sommeil de l'enfant (Mindell et al., 2006). Les professionnels, en étant informés des normes développementales attendues dans le sommeil, pourraient quant à eux identifier les enfants qui présentent un sommeil problématique et proposer des interventions afin de pallier à ces difficultés, empêchant ainsi que les problèmes persistent tout au long de l'enfance, ce qui est souvent le cas sans intervention (Mindell & Owens, 2015). Des études ont d'ailleurs démontré l'efficacité de certaines interventions, notamment des thérapies comportementales, afin de traiter les problèmes de sommeil chez les enfants (voir Meltzer & Mindell, 2014 pour une revue). Ces thérapies peuvent varier dans leurs principes et applications, mais incluent généralement une portion d'éducation auprès des parents sur le sommeil de l'enfant et sur l'importance d'établir une routine autour du moment du coucher. Elles visent de plus à éliminer des pratiques parentales néfastes pour le sommeil de l'enfant et à favoriser le développement de nouvelles pratiques (p.ex. ignorer les pleurs de l'enfant pendant une période déterminée) qui permettent à l'enfant d'apprendre à s'auto-réguler lors du coucher et des éveils nocturnes sans avoir recours à l'intervention des parents.

Aussi, l'article 3 met en lumière le rôle de la relation père-enfant, et plus précisément de l'orientation mentale paternelle, dans le développement de patrons matures de sommeil. Bien que ces résultats devront être reproduits dans des échantillons indépendants avant que l'on puisse en tirer des recommandations d'interventions spécifiques, ils suggèrent pour le moment qu'il pourrait être pertinent de faire de la relation père-enfant une potentielle cible d'intervention pour promouvoir des développements optimaux dans le sommeil des enfants. Il serait notamment pertinent de créer des outils destinés à transmettre de l'information vulgarisée aux pères afin de leur expliquer ce qu'est l'orientation mentale et comment ils peuvent la mettre en pratique avec leur enfant. Les professionnels pourraient aussi observer (directement ou par le biais d'un enregistrement vidéo) des interactions père-enfant et offrir ensuite une rétroaction au père afin de l'amener à mieux percevoir les états mentaux présumés de son enfant et à formuler davantage de commentaires appropriés sur ces états mentaux. Des interventions brèves ayant recours à une telle méthode de rétroaction basée sur des vidéos d'interactions parent-enfant ont été démontrées efficaces auprès de différents types de populations (ex., Dozier et al., 2006; Moss et al., 2011). Ces programmes, jusqu'à présent, ont principalement visé la sécurité d'attachement parent-enfant comme cible d'intervention, mais pourraient représenter une bonne base à partir de laquelle concevoir un programme d'intervention visant à favoriser l'orientation mentale. D'ailleurs, certaines études ont commencé à démontrer la possibilité de favoriser l'orientation mentale, spécifiquement, en utilisant des interventions de rétroaction basée sur des vidéos (Colonnesi et al., 2012; Schacht et al., 2017) ou une séance d'information combinée à l'utilisation d'une application mobile destinée à favoriser l'orientation mentale (Larkin et al., 2019).

Limites de la thèse

Les articles de cette thèse présentent, tel que mentionné dans leur discussion respective, certaines limites qu'il est important de mentionner. Pour commencer, les échantillons utilisés étaient petits, ce qui a pu limiter la puissance statistique et la détection de certains effets. De plus, les échantillons étaient composés en grande majorité de familles d'origine caucasienne présentant un faible risque au niveau socioéconomique. Les résultats obtenus dans le cadre de la thèse seraient donc difficilement généralisables à d'autres types de populations (ex., populations à risque au niveau socioéconomique ou provenant d'autres cultures). La taille modeste et le faible degré de diversité des échantillons pourraient également avoir contribué à une plus faible variabilité dans les patrons de sommeil (ex., faible taux d'enfants présentant des problèmes de sommeil ou un patron de développement anormal) et donc à minimiser les différences interindividuelles retrouvées autour du niveau initial et du taux de changement des courbes de croissance de sommeil. Finalement, pour les articles 2 et 3 ainsi que pour les groupes d'enfants plus jeunes inclus dans l'article 1, les participants avaient un maximum de trois nuits de données d'actigraphie. Bien que cela soit fréquent dans les études utilisant l'actigraphie auprès de jeunes enfants (ex., Scher et al., 2010; So et al., 2005; Ward et al., 2008), il est habituellement recommandé d'utiliser un minimum de cinq nuits afin de s'assurer de la fidélité des données (Acebo et al., 1999).

En conclusion, malgré les limites énoncées ci-haut, les articles de la présente thèse ont permis d'apporter un éclairage sur des questions méthodologiques, développementales et familiales en lien avec le sommeil des enfants mesuré par actigraphie. La thèse a notamment permis de reconnaitre l'importance des agendas de sommeil complétés par les parents dans la cotation des données d'actigraphie, tout en démontrant qu'il serait possible d'inclure dans les études une proportion limitée de données analysées sans un tel agenda. De plus, la thèse a permis de décrire les trajectoires développementales normatives suivies par différents indices de sommeil au cours de la période préscolaire et de décrire les variations intra- et interindividuelles au sein de ces développements. Enfin, en démontrant un lien entre l'orientation mentale paternelle et la maturation des patrons de sommeil à l'âge préscolaire, la thèse contribue à la littérature grandissante sur l'apport de la relation père-enfant dans le développement de l'enfant et permet de proposer des pistes d'intervention afin de favoriser un développement favorable des patrons de sommeil chez l'enfant.

Références citées dans l'introduction et la conclusion

Acebo, C., Sadeh, A., Seifer, R., Tzischinsky, O., Hafer, A., & Carskadon, M. (2005). Sleep/wake patterns derived from activity monitoring and maternal report for healthy 1- to 5- year-old children. *Sleep, 28,* 1568-1577. https://doi.org/10.1093/sleep/28.12.1568

Ainsworth, M., Blehar, M. C., Waters, E., & Wall, S. (1978). *Patterns of attachment: A psychological study of the Strange Situation*. Erlbaum.

Aksan, N., Kochanska, G., & Ortmann, M. R. (2006). Mutually responsive orientation between parents and their young children: Toward methodological advances in the science of relationships. *Developmental Psychology, 42,* 833-848. https://doi.org/10.1037/0012-1649.42.5.833

Anders, T. F., Iosif, A. M., Schwichtenberg, A. J., Tang, K., & Goodlin-Jones, B. L. (2011). Six-month sleep–wake organization and stability in preschool-age children with autism, developmental delay, and typical development. *Behavioral Sleep Medicine, 9*, 92-106. https://doi.org/10 .1080/15402002.2011.557991

Bastien, L., Tétreault, É., & Bernier, A. (2020). Disentangling the direction of associations between sleep and temperament in toddlers. *Behavioral Sleep Medicine*, *18*, 523-536. https://doi.org/ 10.1080/15402002.2019.1629442

Bélanger, M-E., Bernier, A., Simard, V., Bordeleau, S., & Carrier, J. (2015). Objective and subjective measures of sleep among preschoolers: Disentangling attachment security and dependency. *Monographs of the Society for Research in Child Development, 80*, 125-140. https://doi.org/10.1111/mono.12148

Bélanger, M. È., Bernier, A., Simard, V., Desrosiers, K., & Carrier, J. (2015). Sleeping toward behavioral regulation: Relations between sleep and externalizing symptoms in toddlers and preschoolers. *Journal of Clinical Child & Adolescent Psychology. 47*, 366-373. https://doi.org/10.1080/15374416.2015.1079782

Bélanger, M. È., Simard, V., Bernier, A., & Carrier, J. (2014). Investigating the convergence between actigraphy, maternal sleep diaries, and the child behavior checklist as measures of sleep in toddlers. *Frontiers in Psychiatry*, *5*, 158. https://doi.org/10.3389/fpsyt.2014.00158

Bell, B. G., & Belsky, J. (2008). Parents, parenting, and children's sleep problems: Exploring reciprocal effects. *British Journal of Developmental Psychology*, *26*, 579-593. https://doi.org/10. 1348/026151008X285651

Bernier, A., Beauchamp, M. H., Bouvette-Turcot, A. A., Carlson, S. M., & Carrier, J. (2013). Sleep and cognition in preschool years: Specific links to executive functioning. *Child Development*, *84*, 1542-1553. https://doi.org/10.1111/cdev.12063

Bernier, A., Bélanger, M.-È., & Tétreault, É. (2019). The hand that rocks the cradle: The family and parenting context of children’s sleep. In B. H. Fiese, M. Celano, K. Deater-Deckard, E. N. Jouriles, & M. A. Whisman (Eds.), *APA handbook of contemporary family psychology: Applications and broad impact of family psychology* (pp. 137–151). American Psychological Association. https://doi.org/10.1037/0000100-009

Bernier, A., Cimon-Paquet, C., Tétreault, É. (sous presse). Sleep development in preschool predicts executive functioning in early elementary school. In S. Berger (Ed.), *Interdisciplinary Perspectives on the Relation between Sleep and Learning in Early Development* (vol. 60). Advances in Child Development and Behavior. https://doi.org/10.1016/bs.acdb.2020.08.005

Bernier, A., Cimon-Paquet, C., Tétreault, É., Carrier, J., & Matte-Gagné, C. (2020). Prospective relations between sleep in preschool years and academic achievement at school entry. *Journal of Sleep Research*, e13183. https://doi.org/10.1111/jsr.13183

Bernier, A., Tétreault, É., Bélanger, M. È., & Carrier, J. (2017). Paternal involvement and child sleep: A look beyond infancy. *International Journal of Behavioral Development*, *41,* 714-722. https://doi.org/10.1177/0165025416667851

Bordeleau, S., Bernier, A., & Carrier, J. (2012). Longitudinal associations between the quality of parent−child interactions and children's sleep at preschool age. *Journal of Family Psychology*, *26*, 254-262. https://doi.org/10.1037/a0027366

Bornstein, M. H., Putnick, D. L., & Esposito, G. (2017). Continuity and stability in development. *Child Development Perspectives*, *11*, 113-119. https://doi.org/10.1111/cdep.12221

Bright, M. A., Frick, J. E., Out, D., & Granger, D. A. (2014). Individual differences in the cortisol and salivary α-amylase awakening responses in early childhood: Relations to age, sex, and sleep. *Developmental Psychobiology, 56*, 1300-1315. https://doi.org/10.1002/dev.21209.

Bub, K. L., Buckhalt, J. A., & El-Sheikh, M. (2011). Children's sleep and cognitive performance: A cross-domain analysis of change over time. *Developmental Psychology, 47*, 1504-1514. https://doi.org/10.1037/a0025535

Burnham, M. M., Goodlin-Jones, B. L., Gaylor, E. E., & Anders, T. F. (2002). Nighttime sleep-wake patterns and self-soothing from birth to one year of age: A longitudinal intervention study. *Journal of Child Psychology and Psychiatry, 43*, 713–725. https://doi.org/10.1111/ 1469-7610.00076

Cabrera, N., Tamis-LeMonda, C. S., Bradley, R. H., Hofferth, S., & Lamb, M. E. (2000). Fatherhood in the twenty-first century. *Child Development*, *71*, 127-136. https://doi.org/10.1111/ 1467-8624.00126

Calkins, S. D., & Hill, A. (2007). Caregiver influences on emerging emotion regulation. In J.J. Gross (Ed.) *Handbook of emotion regulation* (pp.229-48). New York, NY: Guildford Press Crosby, B., LeBourgeois, M. K., & Harsh, J. (2005). Racial differences in reported napping and nocturnal sleep in 2-to 8-year-old children. *Pediatrics, 115*, 225-232. https://doi.org/ 10.1542/ peds.2004-0815D.

Camerota, M., Propper, C. B., & Teti, D. M. (2019). Intrinsic and extrinsic factors predicting infant sleep: Moving beyond main effects. *Developmental Review*, *53*, 100871. https://doi.org/10.1016/ j.dr.2019.100871

Colonnesi, C., Wissink, I. B., Noom, M. J., Asscher, J. J., Hoeve, M., Stams, G. J. J., Polderman, N., & Kellaert-Knol, M. G. (2013). Basic trust: an attachment-oriented intervention based on mind-mindedness in adoptive families. *Research on Social Work Practice*, *23*, 179-188. https://doi.org/10.1177/1049731512469301

Crosby, B., LeBourgeois, M. K., & Harsh, J. (2005). Racial differences in reported napping and nocturnal sleep in 2-to 8-year-old children. *Pediatrics, 115*, 225-232. https://doi.org/10.1542/ peds.2004-0815D.

Dahl, R. E., & El-Sheikh, M. (2007). Considering sleep in a family context: Introduction to the special issue. *Journal of Family Psychology, 21,* 1–3. https://doi.org/10.1037/0893-3200.21.1.1

Dearing, E., McCartney, K., Marshall, N. L., & Warner, R. M. (2001). Parental reports of children's sleep and wakefulness: Longitudinal associations with cognitive and language outcomes. *Infant Behavior and Development, 24,* 151-170. https://doi.org/10.1016/S0163-6383(01) 00074-1

Dégeilh, F., Bernier, A., Leblanc, É., Daneault, V., & Beauchamp, M. H. (2018). Quality of maternal behaviour during infancy predicts functional connectivity between default mode network and salience network 9 years later. *Developmental Cognitive Neuroscience*, *34*, 53-62. https://doi.org/10.1016/j.dcn.2018.06.003

Dewald, J. F., Meijer, A. M., Oort, F. J., Kerkhof, G. A., & Bögels, S. M. (2010). The influence of sleep quality, sleep duration and sleepiness on school performance in children and adolescents: A meta-analytic review. *Sleep Medicine Reviews*, *14*, 179-189. https://doi.org/10.1016/j.smrv. 2009.10.004

De Wolff, M. S., & Van IJzendoorn, M. H. (1997). Sensitivity and attachment: A meta-analysis on parental antecedents of infant attachment. *Child Development, 68*, 571-591. https://doi.org/10. 1111/ j.1467-8624.1997.tb04218.x

Dozier, M., Peloso, E. Lindheim, O., Gordon, M.K., Manni, M., Sepulveda, S., … Levine, S. (2006). Developing evidence-based interventions for foster children: An example of a randomized clinical trial with infants and toddlers. *Journal of Social Issues, 62*, 767-785. https://doi.org/10.1111/j.1540-4560.2006.00486.x

Dubois-Comtois, K., Pennestri, M. H., Bernier, A., Cyr, C., & Godbout, R. (2019). Family environment and preschoolers' sleep: The complementary role of both parents. *Sleep Medicine*, *58*, 114-122. https://doi.org/10.1016/j.sleep.2019.03.002

Dutil, C., Walsh, J. J., Featherstone, R. B., Gunnell, K. E., Tremblay, M. S., Gruber, R., Weiss, S. K., Cote, K. A., Sampson, M., & Chaput, J. P. (2018). Influence of sleep on developing brain functions and structures in children and adolescents: A systematic review. *Sleep Medicine Reviews*, *42*, 184-201. https://doi.org/10.1016/j.smrv.2018.08.003

El-Sheikh, M., Bub, K. L., Kelly, R. J., & Buckhalt, J. A. (2013). Children’s sleep and adjustment: A residualized change analysis. *Developmental Psychology, 49*, 1591-1601. https://doi.org/10. 1037/ a0030223

El-Sheikh, M., Hinnant, J. B., & Erath, S . A. (2015). VI. Marital conflict, vagal regulation, and children's sleep: A longitudinal investigation. *Monographs of the Society for Research in Child Development*, *80*, 89-106. https://doi.org/ 10.1111/mono.12146

El-Sheikh, M., & Kelly, R. J. (2017). Family functioning and children's sleep. *Child Development Perspectives, 11*, 264-269. https://doi.org/10.1111/cdep.12243

El-Sheikh, M., Kelly, R. J., Bagley, E. J., & Wetter, E. K. (2012). Parental depressive symptoms and children's sleep: the role of family conflict. *Journal of Child Psychology and Psychiatry*, *53*, 806-814. https://doi.org/10.1111/j.1469-7610.2012.02530.x

El-Sheikh, M., Kelly, R. J., Koss, K. J., & Rauer, A. J. (2015). Longitudinal relations between constructive and destructive conflict and couples' sleep. *Journal of Family Psychology, 29*(3), 349-359. https://doi.org/10.1037/fam0000083

El-Sheikh, M., & Sadeh, A. (2015). I. Sleep and development: introduction to the monograph. *Monographs of the Society for Research in Child Development*, *80*, 1-14. https://doi.org/10.1111/mono.12141

Fredriksen, K., Rhodes, J., Reddy, R., & Way, N. (2004). Sleepless in Chicago: Tracking the effects of adolescent sleep loss during the middle school years. *Child Development, 75*, 84-95. https://doi.org/10.1111/j.1467-8624.2004.00655.x

Goodlin-Jones, B. L., Burnham, M. M., Gaylor, E. E., & Anders, T. F. (2001). Night waking, sleep-wake organization, and self-soothing in the first year of life. *Journal of Developmental & Behavioral Pediatrics, 22*, 226–233. https://doi.org/10.1097/00004703-200108000-00003

Goodnight, J. A., Bates, J. E., Staples, A. D., Pettit, G. S., & Dodge, K. A. (2007). Temperamental resistance to control increases the association between sleep problems and externalizing behavior development. *Journal of Family Psychology, 21*, 39-48. https://doi.org/10.1037/08933200.21.1. 39

Gruber, R., Somerville, G., Enros, P., Paquin, S., Kestler, M., & Gillies-Poitras, E. (2014). Sleep efficiency (but not sleep duration) of healthy school-age children is associated with grades in math and languages. *Sleep Medicine*, *15*, 1517–1525. https://doi.org/10.1016/j.sleep.2014.08.009

Gueron-Sela, N., Propper, C. B., Wagner, N. J., Camerota, M., Tully, K. P., & Moore, G. A. (2017). Infant respiratory sinus arrhythmia and maternal depressive symptoms predict toddler sleep problems. *Developmental Psychobiology, 59*, 261–267. https://doi.org/10.1002/dev.21480.

Iglowstein, I., Jenni, O. G., Molinari, L., & Largo, R. H. (2003). Sleep duration from infancy to adolescence: Reference values and generational trends. *Pediatrics, 111*, 302-307. http://pediatrics.aappublications.org/content/pediatrics/111/2/302.full.pdf

Jenni, O. G., & Carskadon, M. A. (2007). Sleep behavior and sleep regulation from infancy through adolescence: Normative aspects. *Sleep Medicine Clinics, 2,* 321-329. https://doi.org/10.1016/j.jsmc.2007.05.001

Jenni, O. G., & LeBourgeois, M. K. (2006). Understanding sleep-wake behavior and sleep disorders in children: The value of a model. *Current Opinion in Psychiatry, 19*, 282-287. https://doi.org/10. 1097/01.yco.0000218599.32969.03

Keller, P. S. (2011). Sleep and attachment. In M. El-Sheikh (Ed.), *Sleep and development: Familial and socio-cultural considerations* (pp. 49-78). Oxford University Press.

Keller, P. S., & El-Sheikh, M. (2011). Children's emotional security and sleep: Longitudinal relations and directions of effects. *Journal of Child Psychology & Psychiatry, 52*, 64-71. https://doi.org/10.1111/j.1469-7610.2010.02263.x

Kocevska, D., Muetzel, R. L., Luik, A.I., Luijk, M.P., Jaddoe, V. W., Verhulst, F.C., White, T., & Tiemeier, H. (2017). The developmental course of sleep disturbances across childhood relates to brain morphology at age 7: The generation R study. *Sleep*, *40*, zsw022. https://doi.org/10.1093 /sleep/zsw022.

Larkin, F., Oostenbroek, J., Lee, Y., Hayward, E., & Meins, E. (2019). Proof of concept of a smartphone app to support delivery of an intervention to facilitate mothers' mind-mindedness. *PloS one*, *14*, e0220948. https://doi.org/10.1371/journal.pone.0220948

Magee, C. A., Gordon, R., & Caputi, P. (2014). Distinct developmental trends in sleep duration during early childhood. *Pediatrics, 133*, e1561-e1567. https://doi.org/10.1542/peds.2013-3806

Mazza, S., Bastuji, H., & Rey, A. E. (2020). Objective and Subjective Assessments of Sleep in Children: Comparison of Actigraphy, Sleep Diary Completed by Children and Parents' Estimation. *Frontiers in Psychiatry*, *11*. https://doi.org/10.3389/fpsyt.2020.00495

McMahon, C. A., & Bernier, A. (2017). Twenty years of research on parental mind-mindedness: Empirical findings, theoretical and methodological challenges, and new directions. *Developmental Review*, *46*, 54-80. https://doi.org/10.1016/j.dr.2017.07.001

Meins, E., Fernyhough, C., Fradley, E., & Tuckey, M. (2001). Rethinking maternal sensitivity: Mothers' comments on infants' mental processes predict security of attachment at 12 months. *The Journal of Child Psychology and Psychiatry and Allied Disciplines*, *42*, 637-648. https://doi.org/ 10.1017/S0021963001007302

Meltzer, L. J., & Mindell, J. A. (2014). Systematic review and meta-analysis of behavioral interventions for pediatric insomnia. *Journal of Pediatric Psychology*, *39*, 932-948. https://doi.org/10.1093/jpepsy/jsu041

Meltzer, L. J., Montgomery-Downs, H. E., Insana, S. P., & Walsh, C. M. (2012). Use of actigraphy for assessment in pediatric sleep research. *Sleep Medicine Reviews*, *16*, 463-475. https://doi.org/ 10.1016/j. smrv.2011.10.002

Meltzer, L. J., & Westin, A. M. (2011). A comparison of actigraphy scoring rules used in pediatric research. *Sleep Medicine, 12,* 793-796. https://doi.org/10.1016/j.sleep.2011.03.011

Miller, A. L., Seifer, R., Crossin, R., & Lebourgeois, M. K. (2015). Toddler's self-regulation strategies in a challenge context are nap-dependent. *Journal of sleep research, 24*, 279-287. https://doi.org/10.1111/jsr.12260

Millikovsky-Ayalon, M., Atzaba-Poria, N., & Meiri, G. (2015). The role of the father in child sleep disturbance: Child, parent, and parent-child relationship. *Infant Mental Health Journal, 36*, 114-127. https://doi.org/10.1002/imhj.21491

Mindell, J. A., Kuhn, B., Lewin, D. S., Meltzer, L. J., & Sadeh, A. (2006). Behavioral treatment of bedtime problems and night wakings in infants and young children. *Sleep,* 29, 1263-1276. https://doi.org/10.1093/sleep/29.10.1263

Mindell, J. A., Li, A. M., Sadeh, A., Kwon, R., & Goh, D. Y. T. (2015). Bedtime routines for young children: A dose-dependent association with sleep outcomes. *Sleep*, *38*, 717-722. https://doi.org/10.5665/sleep.4662

Mindell, J. A., & Owens, J. A. (2015). *A clinical guide to pediatric sleep: Diagnosis and management of sleep problems* (3rd ed.). Lippincott, Williams, & Wilkins.

Mindell, J. A., Sadeh, A., Kohyama, J., & How, T. H. (2010). Parental behaviors and sleep outcomes in infants and toddlers: A cross-cultural comparison. *Sleep Medicine*, *11*, 393-399. https://doi.org/10.1016/j.sleep.2009.11.011.

Mindell, J. A., Telofski, L. S., Wiegand, B., & Kurtz, E. S. (2009). A nightly bedtime routine: Impact on sleep in young children and maternal mood. *Sleep*, *32*, 599-606. https://doi.org/10.1093/sleep/32.5.599

Morrell, J., & Steele, H. (2003). The role of attachment security, temperament, maternal perception, and care-giving behavior in persistent infant sleeping problems. *Infant Mental Health Journal, 24*, 447–468. https://doi.org/10.1002/imhj.10072.

Moss, E., Dubois-Comtois, K., Cyr, C., Tarabulsy, G. M., St-Laurent, D., & Bernier, A. (2011).

Efficacy of a home-visiting intervention aimed at improving maternal sensitivity, child attachment, and behavioral outcomes for maltreated children: A randomized control trial. *Development and Psychopathology, 23*, 195-210. https://doi.org/10.1017/S0954579410000738.

National Sleep Foundation (2004). Sleep in America poll. http://www.sleepfoundation.org/sites/default/files/FINAL%20SOF%202004.pdf

NICHD Early Child Care Research Network (2000). Factors associated with fathers' caregiving activities and sensitivity with young children. *Journal of Family Psychology, 14*, 200-219. https://doi.org/10.1037/0893-3200.14.2.200

Philbrook, L. E., & Teti, D. M. (2016). Bidirectional associations between bedtime parenting and infant sleep: Parenting quality, parenting practices, and their interaction. *Journal of Family Psychology, 30*, 431-441. https://doi.org/10.1037/fam0000198

Plancoulaine, S., Reynaud, E., Forhan, A., Lioret, S., Heude, B., & Charles, M. A. (2018). Night sleep duration trajectories and associated factors among preschool children from the EDEN cohort. *Sleep Medicine*, *48*, 194-201. https://doi.org/10.1016/j.sleep.2018.03.030

Priddis, L. E. (2009). Tuned in parenting and infant sleep patterns. *Early Child Development and Care*, *179*, 259-269. https://doi.org/10.1080/03004430600912132

Rhoades, K. A., Leve, L. D., Harold, G. T., Mannering, A. M., Neiderhiser, J. M., Shaw, D. S., Natsuaki, M. N., & Reiss, D. (2012). Marital hostility and child sleep problems: Direct and indirect associations via hostile parenting. *Journal of Family Psychology, 26*, 488–498. https://doi.org/10.1037/a0029164

Sadeh, A. (2015). Sleep assessment methods. *Monographs of the Society for Research in Child Development, 80*, 33-48. https://doi.org/10.1111/mono.12143

Sadeh, A., & Anders, T. F. (1993). Infant sleep problems: Origins, assessment, interventions. *Infant Mental Health Journal*, *14,* 17-34. https://doi.org/10.1002/1097-0355

Sadeh, A., Tikotzky, L., & Scher, A. (2010). Parenting and infant sleep. *Sleep Medicine Reviews, 14*, 89-96. https://doi.org/10.1016/j.smrv.2009.05.003

Schacht, R., Meins, E., Fernyhough, C., Centifanti, L. C. M., Bureau, J.-F., & Pawlby, S. (2017). Proof of concept of a mind-mindedness intervention for mothers hospitalized for severe mental illness. *Development and Psychopathology, 29*, 555–564. http://doi.org/10.1017/ S0954579417000177.

Scher, A., & Asher, R. (2004). Is attachment security related to sleep–wake regulation? Mothers' reports and objective sleep recordings. *Infant Behavior and Development, 27*, 288-302. doi:10.1016/S0163-6383(04)00034-7

Scher, A., Epstein, R., & Tirosh, E. (2004). Stability and changes in sleep regulation: A longitudinal study from 3 months to 3 years. I*nternational Journal of Behavioral Development, 28*, 268-274. https://doi.org/10.1080/01650250344000505

Scher, A., Hall, W. A., Zaidman-Zait, A., & Weinberg, J. (2010). Sleep quality, cortisol levels, and behavioral regulation in toddlers. *Developmental Psychobiology, 52*, 44-53. https://doi.org/10 .1002/dev.20410

Schoch, S. F., Kurth, S., & Werner, H. (2020). Actigraphy in sleep research with infants and young children: Current practices and future benefits of standardized reporting. *Journal of Sleep Research*, e13134. https://doi.org/10.1111/jsr.13134

Schoppe-Sullivan, S. J., & Fagan, J. (2020). The evolution of fathering research in the 21st century: Persistent challenges, new directions. *Journal of Marriage and Family, 82,* 175-197. https://doi.org/10. 1111/jomf.12645

Simard, V., Lara-Carrasco, J., Paquette, T., & Nielsen, T. (2011). Breastfeeding, maternal depressive mood and room sharing as predictors of sleep fragmentation in 12-week-old infants: A longitudinal study. *Early Child Development and Care*, *181*, 1063-1077. https://doi.org/10. 1080/03004430. 2010.513434

Silva, G. E., Goodwin, J. L., Parthasarathy, S., Sherrill, D. L., Vana, K. D., Drescher, A. A., & Quan, S. F. (2011). Longitudinal association between short sleep, body weight, and emotional and learning problems in Hispanic and Caucasian children. *Sleep, 34*, 1197-1205. https://doi.org/ 10.5665/SLEEP.1238

Simard, V., Chevalier, V., & Bédard, M. M. (2017). Sleep and attachment in early childhood: A series of meta-analyses. *Attachment & Human Development*, *19*, 298-321. https://doi.org/10. 1080/14616734.2017.1293703

Smithson, L., Baird, T., Tamana, S. K., Lau, A., Mariasine, J., Chikuma, J., … Mandhane, P. J. (2018). Shorter sleep duration is associated with reduced cognitive development at two years of age. *Sleep Medicine*, *48*, 131–139. https://doi.org/10.1016/j.sleep.2018.04.005

So, K., Buckley, P. A. T., Adamson, T. M., & Horne, R. S. (2005). Actigraphy correctly predicts sleep behavior in infants who are younger than six months, when compared with polysomnography. *Pediatric Research, 58*, 761-765. https://doi.org/10.1203/01.PDR.0000180568 .97221.56

Stalder, T., Bäumler, D., Miller, R., Alexander, N., Kliegel, M., & Kirschbaum, C. (2013). The cortisol awakening response in infants: Ontogeny and associations with development-related variables. *Psychoneuroendocrinology, 38*, 552–559. https://doi.org/10.1016/j.psyneuen. 2012.07.015.

Staples, A. D., Bates, J. E., & Petersen, I. T. (2015). Ix. Bedtime routines in early childhood: Prevalence, consistency, and associations with nighttime sleep. *Monographs of the Society for Research in Child Development, 80*, 141-159. https://doi.org/10.1111/mono.12149

Tétreault, É., Bouvette-Turcot, A.-A., Bernier, A., & Bailey, H. (2017). Associations between early maternal sensitivity and children's sleep throughout early childhood. *Infant and Child Development, 26*, e2004. https://doi.org/10.1002/icd.2004

Teti, D. M., Kim, B. R., Mayer, G., & Countermine, M. (2010). Maternal emotional availability at bedtime predicts infant sleep quality. *Journal of Family Psychology*, *24*, 307-315. https://doi.org/ 10.1037/a0019306

Tikotzky, L., Sadeh, A., & Glickman-Gavrieli, T. (2011). Infant sleep and paternal involvement in infant caregiving during the first 6 months of life. *Journal of Pediatric Psychology*, *36*, 36-46. https://doi.org/10.1093/jpepsy/jsq036

Tikotzky, L., Sadeh, A., Volkovich, E., Manber, R., Meiri, G., & Shahar, G. (2015). Infant sleep development from 3 to 6 months postpartum: Links with maternal sleep and paternal involvement. *Monographs of the Society for Research in Child Development*, *80*, 107-124. https://doi.org/10.1111/mono.12147

Touchette, E., Côté, S. M., Petit, D., Liu, X., Boivin, M., Falissard, B., Tremblay, R. E., & Montplaisir, J. Y. (2009). Short nighttime sleep-duration and hyperactivity trajectories in early childhood. *Pediatrics, 124*, 985-993. https://doi.org/10.1542/peds.2008-2005

Touchette, É., Petit, D., Paquet, J., Boivin, M., Japel, C., Tremblay, R. E., & Montplaisir, J. Y. (2005). Factors associated with fragmented sleep at night across early childhood. *Archives of Pediatrics and Adolescent Medicine*, *159*, 242-249. https://doi.org/10.1001/archpedi.159.3.242

Touchette, E., Petit, D., Tremblay, R. E., Boivin, M., Falissard, B., Genolini, C., & Montplaisir, J.Y. (2008). Associations between sleep duration patterns and overweight/obesity at age 6. *Sleep, 31*, 1507-1514. https://doi.org/10.1093/sleep/31.11.1507

Vaughn, B., El-Sheikh, M., Shin, N., Elmore-Staton, L., Krzysik, L., & Monteiro, L. (2011). Attachment representations, sleep quality and adaptive functioning in preschool age children. *Attachment and Human Development*, *13*, 525-540. https://doi.org/10.1080/14616734.2011. 608984

Ward, T. M., Gay, C., Anders, T. F., Alkon, A., & Lee, K. A. (2008). Sleep and napping patterns in 3-to-5-year old children attending full-day childcare centers. *Journal of Pediatric Psychology, 33,* 666-672. https://doi.org/10.1093/jpepsy/jsm102

Weinraub, M., Bender, R. H., Friedman, S. L., Susman, E. J., Knoke, B., Bradley, R., Houts, R., & Williams, J. (2012). Patterns of developmental change in infants' nighttime sleep awakenings from 6 through 36 months of age. *Developmental Psychology, 48*, 1511-1528. https://doi.org/10. 1037/ a0027680

Williams, K. E., Nicholson, J. M., Walker, S., & Berthelsen, D. (2016). Early childhood profiles of sleep problems and self-regulation predict later school adjustment. *British Journal of Educational Psychology*, *86*, 331-350. https://doi.org/10.1111/bjep.12109

Williamson, A. A., Mindell, J. A., Hiscock, H., & Quach, J. (2019). Sleep Problem Trajectories and Cumulative Socio-Ecological Risks: Birth to School-Age. *The Journal of Pediatrics*, *215*, 229-237. https://doi.org/10.1016/j.jpeds.2019.07.055

Zeegers, M. A., de Vente, W., Nikolić, M., Majdandžić, M., Bögels, S. M., & Colonnesi, C. (2018). Mothers' and fathers' mind-mindedness influences physiological emotion regulation of infants across the first year of life. *Developmental Science*, *21*, e12689. https://doi.org/10.1111/desc. 12689

ANNEXE A

Agenda de sommeil pour les enfants de 2 à 8 ans

AGENDA DE SOMMEIL

Consignes:

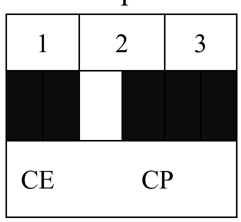
Afin de nous permettre d'avoir une idée adéquate du sommeil de votre enfant, il est très important que vous remplissiez l'agenda pour toute la période recommandée, soit 3 jours entiers. Voici quelques consignes:

- Indiquez clairement la date à chaque jour.
- Noircissez l'espace correspondant aux périodes de sommeil.
- Les espaces laissés en blanc correspondent aux périodes d'éveil. Faites attention de ne pas noircir les périodes que vous passées à endormir votre enfant. Par exemple, si vous le bercez avant de le coucher et qu'il est encore éveillé, il ne faut pas noircir cette période.
- Indiquez, avec la lettre correspondante, l'endroit où votre enfant dort dans l'espace à cet effet, situé sous les espaces noircis. La correspondance est la suivante :

  CE – Chambre Enfant CP – Chambre Parent Di – Divan
  Po – Poussette Vo – Voiture * - Autre, précisez dans les remarques

  Voici un exemple:

  Votre enfant dormait dans son lit jusqu'à 2h00 am, se réveille et vous lui donnez un biberon dans vos bras pendant 30 minutes. Puis, vous retournez vous coucher dans votre lit et l'amenez avec vous. Vous devriez indiquez ces informations comme suit :



- Indiquez tout événement particulier pouvant représenter un changement dans la routine habituelle dans la section REMARQUES. Par exemple, la visite tardive d'invités ayant repoussé l'heure habituelle de sommeil.
- Voici l'équivalence indiquant la période de la journée dans l'agenda:
  - Le «0 » correspond à la période entre 0h00 et 1h00
  - Le «1» correspond à la période entre 1h00 et 2h00

  …
  - Le «11» correspond à la période entre 11h00 et 12h00
  - Le «12» correspond à la période entre 12h00 et 13h00
  - Le «13» correspond à la période entre 13h00 et 14h00

  …
  - Le «22» correspond à la période entre 22h00 et 23h00
  - Le «23» correspond à la période entre 23h00 et 24h00

- Si votre enfant fréquente la garderie, informez-vous des périodes de sommeil à chaque jour auprès de l'éducateur(trice) de votre enfant. Indiquez les périodes de garderie dans la section REMARQUES.
- Si vous avez des questions ou des difficultés, contactez-nous au numéro (514) 343-2337.

AGENDA DE SOMMEIL

	Période de la journée																						
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23

Endroit : CE – Chambre Enfant CP – Chambre Parent Di – Divan

Po –Poussette Vo – Voiture * - Autre, à précisez dans les remarques

Indiquez tout événement particulier pouvant avoir influencé votre enfant lors de ces journées.

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ANNEXE B

Agenda de sommeil pour les enfants de 8 à 11 ans

AGENDA DU SOMMEIL

Consignes:

Afin de nous permettre d'avoir une idée adéquate du sommeil de votre enfant, il est très important que vous remplissiez le questionnaire suivant pour toute la période recommandée, soit **pendant 7 jours.** Voici quelques consignes importantes:

- La montre doit être portée par votre enfant à partir de l'heure du souper ou tout de suite après le bain du soir, et pour toute la nuit. Veuillez SVP la lui enlever le lendemain matin avant son départ pour l'école, soit vers l'heure du déjeuner.
- Remplissez ce questionnaire pour les 7 jours où votre enfant porte l'actigraphe.
- Indiquez clairement la date à chaque jour.
- Répondez SVP à chacune des quatre questions pour chaque jour.

Voici un exemple:

JOUR 1

Date : ______________	À quelle heure votre enfant s'est-il (elle) couché(e) ?	20h
	À quelle heure votre enfant s'est-il (elle) levé(e) le lendemain matin ?	6h30
	Était-il (elle) malade d'une façon qui ait pu perturber son sommeil ?	non
	Semble-t-il (elle) s'être réveillé(e) pendant cette nuit ?	oui

- Indiquez tout événement particulier pouvant représenter un changement dans la routine habituelle dans la section REMARQUES. Par exemple, la visite tardive d'invités ayant repoussé l'heure habituelle de sommeil.
- Si vous avez des questions ou des difficultés, contactez-nous au numéro (514) 343-2337.

*****Mettre l'actigraphe sur le poignet non-dominant*****

JOUR 1

Date : ______________	À quelle heure votre enfant s'est-il (elle) couché(e) ?	
	À quelle heure votre enfant s'est-il (elle) levé(e) le lendemain matin ?	
	Était-il (elle) malade d'une façon qui ait pu perturber son sommeil ?	
	Semble-t-il (elle) s'être réveillé(e) pendant cette nuit ?	

JOUR 2

Date : ______________	À quelle heure votre enfant s'est-il (elle) couché(e) ?	
	À quelle heure votre enfant s'est-il (elle) levé(e) le lendemain matin ?	
	Était-il (elle) malade d'une façon qui ait pu perturber son sommeil ?	
	Semble-t-il (elle) s'être réveillé(e) pendant cette nuit ?	

JOUR 3

Date : ______________	À quelle heure votre enfant s'est-il (elle) couché(e) ?	
	À quelle heure votre enfant s'est-il (elle) levé(e) le lendemain matin ?	
	Était-il (elle) malade d'une façon qui ait pu perturber son sommeil ?	
	Semble-t-il (elle) s'être réveillé(e) pendant cette nuit ?	

JOUR 4

Date : ______________	À quelle heure votre enfant s'est-il (elle) couché(e) ?	
	À quelle heure votre enfant s'est-il (elle) levé(e) le lendemain matin ?	
	Était-il (elle) malade d'une façon qui ait pu perturber son sommeil ?	
	Semble-t-il (elle) s'être réveillé(e) pendant cette nuit ?	

JOUR 5

Date : ______________	À quelle heure votre enfant s'est-il (elle) couché(e) ?	
	À quelle heure votre enfant s'est-il (elle) levé(e) le lendemain matin ?	
	Était-il (elle) malade d'une façon qui ait pu perturber son sommeil ?	
	Semble-t-il (elle) s'être réveillé(e) pendant cette nuit ?	

JOUR 6

Date : ______________	À quelle heure votre enfant s'est-il (elle) couché(e) ?	
	À quelle heure votre enfant s'est-il (elle) levé(e) le lendemain matin ?	
	Était-il (elle) malade d'une façon qui ait pu perturber son sommeil ?	
	Semble-t-il (elle) s'être réveillé(e) pendant cette nuit ?	

JOUR 7

Date : ______________	À quelle heure votre enfant s'est-il (elle) couché(e) ?	
	À quelle heure votre enfant s'est-il (elle) levé(e) le lendemain matin ?	
	Était-il (elle) malade d'une façon qui ait pu perturber son sommeil ?	
	Semble-t-il (elle) s'être réveillé(e) pendant cette nuit ?	

REMARQUES: Indiquez tout événement particulier pouvant avoir influencé votre enfant lors de ces journées.

____

Temps où l'enfant ne portait PAS l'actigraphe :

____

ANNEXE C

Questionnaire d'engagement paternel

Paquette, D., Bolté, C., Turcotte, G., Dubeau, D., & Bouchard, C. (2000). A new typology of fathering: Defining and associated variables. *Infant & Child Development*, *9*, 213-230. doi:10.1002/1522-7219

Questionnaire d'engagement paternel

Voici une liste d'activités ou de tâches que peuvent faire des parents. Il se peut que votre conjointe s'occupe plus que vous de certains aspects de la vie de votre famille, et le contraire pour d'autres aspects. Inscrivez à quelle fréquence vous faites vous-même chacune de ces activités.

Jamais	Une fois par mois	2 à 3 fois par mois	Une fois par semaine	Plusieurs fois par semaine	Chaque jour	Ne s'applique pas
1	2	3	4	5	6	7

1. Préparer les repas	
2. Donner à manger ou à boire à votre enfant	
3. Se tirailler en jeu avec votre enfant (se chamailler)	
4. Faire la vaisselle	
5. Lui donner le bain	
6. Chatouiller votre enfant	
7. Habiller votre enfant	
8. Regarder avec lui une émission pour enfants à la télévision	
9. Faire le lavage	
10. Mettre votre enfant au lit le soir	
11. Écouter de la musique avec votre enfant	
12. Superviser la routine du matin (déjeuner, habillage, etc.)	
13. Transporter votre enfant sur votre dos en jouant	
14. Prendre soin des cheveux de votre enfant	
15. Faire rire votre enfant	
16. Le prendre dans vos bras lorsqu'il le demande	
17. Raconter des anecdotes concernant votre enfant à vos collègues de travail ou des amis(es)	
18. Corriger votre enfant à cause de ses manières à table	
19. Réprimander votre enfant parce qu'il dérange	
20. Souligner un bon coup, une finesse de votre enfant	

Jamais	Une fois par mois	2 à 3 fois par mois	Une fois par semaine	Plusieurs fois par semaine	Chaque jour	Ne s'applique pas
1	**2**	**3**	**4**	**5**	**6**	**7**

21. Nettoyer la maison (balai, aspirateur, époussetage)	
22. Caresser, minoucher votre enfant	
23. Faire participer votre enfant aux activités des adultes (cuisine, ménage)	
24. Gronder votre enfant parce qu'il a désobéi	

S.V.P. Utiliser l'échelle suivante pour le reste du questionnaire.

Jamais	À l'occasion	Régulièrement	Souvent	Très souvent	Ne s'applique pas
1	**2**	**3**	**4**	**5**	**7**

25. Accompagner votre enfant chez des amis, des parents ou des voisins	
26. Sortir les vidanges	
27. Aller au parc avec votre enfant	
28. Laver les oreilles de votre enfant	
29. Parler de votre enfant à des amis, des voisins, des collègues de travail, etc.	
30. S'occuper de la réparation de l'auto	
31. Faire des sorties avec votre enfant	
32. S'assurer que la maison soit sécuritaire pour votre enfant	
33. Initier votre enfant à des sports (nager, patiner, monter à bicyclette, lancer une balle, etc.)	
34. Aménager la maison (décoration, réparations, etc.)	
35. S'occuper de votre enfant lorsqu'il est malade	
36. Parler de vos joies ou de vos problèmes de parent	
37. Rassurer votre enfant lorsqu'il a peur	
38. Penser à votre enfant en son absence	
39. Prendre rendez-vous avec le médecin ou le dentiste lorsque votre enfant en a besoin	
40. Surveiller votre enfant lorsqu'il joue dehors	
41. Magasiner (meubles, vêtements, objets divers nécessaires pour la maison, etc.)	
42. Donner les premiers soins à votre enfant lorsqu'il se blesse	
43. Punir votre enfant parce qu'il a fait un mauvais coup (briser quelque chose, blesser quelqu'un, etc.)	

44. Vous lever la nuit pour votre enfant	
45. Proposer des jeux éducatifs pour votre enfant	
46. Chercher à savoir auprès de votre enfant ce qui ne va pas	
47. Féliciter votre enfant quand il réussit quelque chose	
48. Consoler votre enfant lorsqu'il pleure	
49. Prévoir les achats nécessaires pour votre enfant (vêtements, chaussures, médicaments, etc.)	
50. Calmer votre enfant	
51. Regarder les photographies de votre enfant	
52. Dire à votre enfant que vous l'aimez	
53. Encourager votre enfant à réussir quelque chose de difficile (Exemple: marcher)	
54. Vous souvenir de votre enfant lorsqu'il était plus jeune	
55. Intervenir rapidement lorsque votre enfant montre des signes de détresse ou d'inconfort	
56. Montrer de nouveaux jeux à votre enfant	

ANNEXE D

Grille de codification pour l'orientation mentale

Meins, E., Fernyhough, C., Fradley, E., & Tuckey, M. (2001). Rethinking maternal sensitivity: Mothers' comments on infants' mental processes predict security of attachment at 12 months. *The Journal of Child Psychology and Psychiatry and Allied Disciplines*, *42*, 637-648. https://doi.org/10.1017/S0021963001007302

<u>Numéro de la famille :</u>

Total de commentaires mentaux pertinents :

Total de commentaires mentaux non-pertinents :

Total de commentaires :

Commentaires sur l'état mental	Commentaires sur les processus mentaux	Commentaires sur le degré d'engagement de l'enfant	Commentaires sur les tentatives de l'enfant de « manipuler » les pensées des autres	Tentative d'interpréter les pensées de l'enfant
Total :	**Total :**	**Total :**	**Total :**	**Total :**

ANNEXE E

Grille de codification pour la qualité des interactions père-enfant

Aksan, N., Kochanska, G., & Ortmann, M. R. (2006). Mutually responsive orientation between parents and their young children: Toward methodological advances in the science of relationships. *Developmental Psychology, 42,* 833-848. doi:10.1037/0012-1649.42.5.833

Scores
1) Very untrue dyad – Poor relationship
2) Quite/rather untrue dyad – Not a very good relationship
3) Average - Dyad fluctuates between low and high MRO or is average
4) Quite/rather true dyad – Reasonable MRO and relationship
5) Very true dyad – Very high MRO and excellent relationchip

Communication harmonieuse	**A.** L'interaction coule doucement, est fluide et harmonieuse.
	B. La communication se fait sans effort et est réciproque.
	C. Les dialogues favorisent l'intimité et la complicité.
Coopération mutuelle	**A.** La dyade est capable d'accepter de façon tacite les rôles de chacun.
	B. Les messages subtils ou implicites sont suffisants pour obtenir une bonne coopération OU la coopération se construit facilement.
	C. Le parent et l'enfant adoptent une posture, une attitude ouverte et réceptive face aux tentatives d'influence de l'autre.
	D. Turn-taking/imitation.
Ambiance émotionnelle	**A.** L'atmosphère émotionnelle globale est positive et chaleureuse.
	B. La dyade s'engage dans des séquences évidentes d'affects négatifs (inversé).
	C. La dyade s'engage dans des séquences de joie évidentes.
	D. Présences de démonstrations spontanées d'affection.