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UMI
ATTENTION-DEFICIT/HYPERACTIVITY DISORDER AND SLEEP PROBLEMS

by

Penny Corkum

A thesis submitted in conformity with the requirements
for the degree of a Doctorate of Philosophy
Graduate Department of Education
University of Toronto

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ATTENTION-DEFICIT/HYPERACTIVITY DISORDER AND SLEEP PROBLEMS

Penny Corkum, Doctorate of Philosophy, 1999
Graduate Department of Education, University of Toronto

ABSTRACT

Objective: This thesis tests two opposing explanations for sleep difficulties in children with ADHD: 1) sleep problems are intrinsic to ADHD; and 2) sleep problems are extrinsic to ADHD.

Method: Three research studies were conducted as part of this thesis. The first study was a box-score analysis of previous research that evaluated for consistency in findings across studies and highlighted methodological issues. The second study tested the specificity of sleep problems to ADHD utilizing sleep questionnaires completed by parents of four groups of children (n = 172): unmedicated ADHD, medicated ADHD, clinical, and normal comparison groups. The third study examined six sleep parameters in 50 children (25 ADHD, 25 normal comparison) to verify sleep problems in children with ADHD through the use of multiple measures (i.e., questionnaires, sleep diaries, and actigraphy).

Results: The main finding from each study is outlined below. Firstly, it was found that across previous research, there is little consistent evidence for sleep problems in children with ADHD. Secondly, sleep problems were not found to be specific to ADHD, but were also found in a clinical comparison group. Moreover, specific sleep problems were related to stimulant medication use and comorbidity (e.g., oppositional defiant disorder and anxiety disorders). Thirdly, although sleep problems were reported by parents on a retrospective questionnaire, the majority of these sleep problems were not verified through sleep diaries or actigraphy. The only consistent finding across measures were that children with ADHD had longer sleep duration and more bedtime resistance (i.e., challenging behaviours).

Conclusions: The majority of the results across the three studies provide support for the notion that many of the commonly reported sleep problems in children with ADHD may be extrinsic in nature. More specifically, challenging behaviours during bedtime routines may account for these sleep problems. Clinically, it would seem that behavioural interventions should be the first line of treatment for sleep problems in children with ADHD.
This thesis is dedicated to Colleen Bacon,
the teachers and students at the Douglas Academy.

“To give of oneself, and to ease the pain of a child, to know even one life has breathed
easier because you have lived... this is to have success.”

R.W. Emerson
ACKNOWLEDGEMENTS

I would like to thank my committee members for their support of my research and my personal and professional development. More specifically, I would like to thank each individual member for a special attribute they uniquely contributed to my development: Rosemary for her high level of integrity, her kind and gentle support and her wealth of knowledge about ADHD; Harvey for his ability to help me reach a higher level of expectation and his broad knowledge of sleep processes; Tom for his objective opinions and contribution to my development as a clinical psychologist; and Shielah for her ability to make statistics seem easy and her generosity in helping me during my trials and tribulations.

Also, I would like to thank my family for their understanding and support, particularly my mother who gave me something no-one else could give and my husband who willingly placed himself second to my studies on numerous occasions. A special thanks to my many friends, especially Pearl (my personal editor and friend) and Barb, both of whom were never more than a phone call away!
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CHAPTER 1

Statement of the problem
Attention-Deficit/Hyperactivity Disorder (ADHD) is comprised of three core symptoms - difficulties with attention, impulsivity and hyperactivity, and is the most common problem presented to children's mental health services (Barkley, 1990). The current diagnostic classification, the *Diagnostic and Statistical Manual-IV* (American Psychiatric Association, 1994), identifies three subtypes of ADHD: Predominately Inattentive, Predominately Hyperactive-Impulsive, and Combined subtypes. The prevalence of the disorder is conservatively estimated to occur in three to six percent of school-aged children, with boys being diagnosed at least three times more frequently than girls (Szatmari et al., 1987). Although once thought of as a childhood disorder, it is now believed that the symptoms of ADHD can persist across the life span, with age and gender specific changes in its manifestation (Barkley, 1990). The disorder has been found to have a negative impact on a child's functioning within the family, school and community (Barkley, 1990).

In addition to the core symptomatology (i.e., inattention, impulsiveness and restlessness), ADHD is associated with other problems (e.g., academic underachievement, poor social relations) and shows a high rate of comorbidity with other clinical disorders (Barkley, 1990). The rates of comorbidity in latency-aged children with ADHD vary depending on the sample and methodology, however, the majority of children with ADHD meet diagnostic criteria for at least one other psychiatric disorder (see Tannock 1998 for a review). Other externalizing disorders such as oppositional defiant disorder and conduct disorder, are the most common comorbid diagnosis with ADHD, with an estimated rate between 40 to 90 percent. Internalizing disorders, such as anxiety and mood disorders, and
learning disabilities are also frequently comorbid with ADHD, with an estimated frequency of approximately 25 percent. It is believed that many of the problems thought to be associated with ADHD may in fact be attributable to a comorbid disorder (Jensen et al., 1997).

In addition to comorbid externalizing and internalizing disorders associated with ADHD, it is also believed that these children suffer from a variety of sleep difficulties. Early documentation indicates that children with ADHD often present with sleep problems (Luisada, 1969). One particular sleep problem, "restless sleep", had been included in the diagnostic criteria for Attention Deficit Disorder in the *Diagnostic and Statistical Manual-III* (American Psychiatric Association, 1980), although it has been excluded in more recent versions. Also, items assessing sleep problems have been included in a number of popular child rating scales (e.g., Conners Parent Rating Scale; Goyette et al., 1978). These rating scales, including the sleep items, continue to be used for diagnostic purposes in both clinical and research settings. It appears that the inclusion of sleep problems in the *DSM-III* and child rating scales were based primarily on clinical observations that identified an association between ADHD and sleep problems, rather than a theory that implicated sleep disturbances in ADHD.

While treatment for ADHD is multi-faceted, the most common component is stimulant medication, particularly methylphenidate (Denney and Rapport, 1999). Importantly, stimulant medication is also indicated for the treatment of sleepiness in patients with narcolepsy, a primary sleep disorder. It is estimated that 75 percent of children diagnosed as ADHD are treated with stimulant medication (Barkley, 1990). Of
the children prescribed methylphenidate, 70-80 percent of children show a marked reduction in core and associated symptoms (Spencer et al., 1996). Stimulant medication use in children is deemed to be safe, however, as with all medications it has some side-effects. The exact nature of these side-effects remains controversial. An increase in the rate of sleep problems has been one of the most consistent side-effects found in both acute trials (Barkley, 1990) and long term studies (Schachar et al., 1997).

Research exploring the relationship between ADHD and sleep problems is relatively new, with the majority of studies being conducted since the early 1980's. This is not surprising as interest in the field of pediatric sleep medicine has existed from this time (Sheldon, 1996). The development of standards for evaluating sleep in children has proven to be a formidable task. The reasons for this are multifaceted: there are many changes in sleep over the span of childhood; there is significant variability in same-aged individuals; and procedures used with adults have not always been appropriate for use with children. However, as it has become more apparent that sleep plays an important role in daytime functioning, the need for information on pediatric sleep has increased.

To date, the exact relationship between sleep problems and ADHD is unknown. The most common explanation for sleep problems in children with ADHD is that these sleep problems are intrinsic to ADHD (i.e., internally generated and specific to an ADHD diagnosis). It has been proposed that children with ADHD may suffer from a primary sleep disorder (Dahl et al., 1991; Guilleminault et al., 1982; Picchietti and Walters, 1994; Sheldon et al., 1991; Weinberg, 1990), with the strongest interpretation of this postulate indicating that ADHD symptoms may be secondary to the sleep disorder. Another
explanation is that sleep problems in children with ADHD may be due to dysregulation of arousal (Busby and Pivik, 1985; Busby et al., 1985; Greenhill et al., 1983; Tirosh et al., 1993). Since dysregulation of arousal has been viewed as a core component of ADHD (Barkley, 1997), sleep difficulties could result in sleep deprivation that may exacerbate problems with attention, impulsivity and hyperactivity.

An alternative explanation is that sleep problems in children with ADHD may be extrinsic in nature. It may be that the sleep problems most commonly associated with ADHD are a manifestation of challenging behaviour, rather than internally generated. For example, the majority of children with ADHD also reach criteria for an oppositional defiant disorder that is manifested in challenging behaviours, particularly in responding to expectations for appropriate behavioural conduct. The extrinsic explanation of sleep problems was originally conceptualized during the course of working with medication naive children with ADHD whose parents often commented on behavioural difficulties surrounding bed and wake routines. To quote one parent "from the time I call him to go to bed until he falls asleep it is a nightmare, he does not comply, argues, and complains, however, once asleep he sleeps like a rock, then we start all over again the next day!"

Chapter 2 reviews the existing literature that examines the relationship between ADHD and sleep disturbances. Previous research addressing sleep problems in children with ADHD is examined through the use of a "box-score" analysis. The goal of this chapter is to identify which sleep problems have consistently been found to be problematic in children with ADHD and to highlight the methodological issues pertinent to sleep research in children with ADHD.
Chapter 3 presents an empirical research study using parental questionnaires of sleep problems in four groups of children (total sample size = 172): ADHD unmedicated, ADHD medicated, clinical comparison, and normal comparison. The goal of this study is to test the specificity of sleep problems to ADHD. If sleep problems are intrinsic to children with ADHD, then it would be predicted that particular sleep problems would be specific to these children. Alternatively, if sleep problems are extrinsic to ADHD, then it is predicted that sleep problems would be similar between the ADHD and clinical comparison groups.

Chapter 4 presents data from a study that employed multiple measures of sleep (parent questionnaire, sleep diaries and actigraphy) on a subsample of 50 children (25 in both the ADHD and normal comparison groups) recruited from the original sample. If sleep problems are intrinsic to ADHD, then it would be predicted that these sleep problems could be verified through the use of objective measures (e.g., actigraphy) and that there would be indicators that these children may be suffering from sleep deprivation. If sleep problems are extrinsic to ADHD, then it would be predicted that sleep problems reported by parents would not be verified by objective measures and that there would be no indicators of sleep deprivation in children with ADHD.

Chapter 5 provides an integration of the results from across the three studies contained within this thesis. In addition, this chapter includes the limitations of the research, new directions for future research, and clinical implications based on the findings of the research conducted for this thesis.
Footnote

1 This thesis is comprised of several published and submitted manuscripts. In making each of these self-contained, overlap of the text of some of the chapters was unavoidable.
CHAPTER 2

Sleep Disturbances in Children with Attention-Deficit/Hyperactivity Disorder: A Systematic Review of the Literature

Objective: To evaluate the relationship between sleep disturbances and attention-deficit/hyperactivity disorder (ADHD).

Method: Empirical research published since 1970 on sleep disturbances in children with ADHD was systematically reviewed. A "box-score" approach was used to examine consistency of findings across the studies, which used different outcome measures.

Results: Although subjective accounts of sleep disturbances in ADHD were prevalent, objective verification of these disturbances was less robust. The only consistent objective findings were that children with ADHD displayed more movements during sleep, but did not differ from normal controls in total sleep time. An additional finding was that stimulant medication led to changes in the sleep of children with ADHD (e.g., prolonged sleep latency, increased length of onset to first Rapid Eye Movement cycle), but these changes were believed to be non-pathological.

Conclusions: The exact nature of the sleep problems in children with ADHD remains to be determined. Many of the relevant issues have not been adequately addressed. Factors such as poorly defined diagnostic groups, small sample sizes, few studies, and methodological and procedural limitations make it difficult to determine the relationship between ADHD and sleep problems.
Attention-Deficit/Hyperactivity Disorder (ADHD) is the most common problem presented to children's mental health services. The disorder affects approximately five percent of school-aged children (American Psychiatric Association, 1994). ADHD is characterized as a heterogeneous combination of several disruptive behaviours, academic underachievement and poor social relations (e.g., Barkley, 1990). The core symptoms of this disorder include varying degrees of inattention, impulsiveness and restlessness. Because these symptoms have long been known to be characteristics of sleep deprivation (Kleitman, 1965), the role of sleep-wakefulness in ADHD merits close scrutiny. Indeed, Weinberg and Brumback (1990) speculated about a disorder similar to ADHD, named Primary Disorder of Vigilance. Many of the characteristics of Primary Disorder of Vigilance overlap with ADHD, however, there is a substantial focus on sleepiness in these children.

Problems with sleep have been associated with ADHD and were previously included as one of the *DSM-III* diagnostic criteria for Attention Deficit Disorder (ADD), although it has not been included in the last two versions of the *DSM* (American Psychiatric Association, 1980, 1987, 1994). Sleep problems are also presently included on a number of child rating scales used as part of the diagnostic procedures for ADHD (e.g., Conners Parent Rating Scale; Goyette et al., 1978). The rationale for including these items appears to be based on clinical observations that identified an association between ADHD and sleep disturbances, rather than a theory that implicates sleep disturbances in ADHD. Sleep is known to be affected by environmental factors, genetic factors, medical factors, and biological influences. Therefore, the study of sleep in children with ADHD
allows for the opportunity to begin to evaluate the relative importance of biological and psychosocial factors, to evaluate various theories of ADHD, and to explore the possibility of several underlying etiologies of the subtypes and comorbidities of ADHD. Although there exists many clinical observations and theoretical speculations regarding the relationship between ADHD and sleep disturbances, there is little empirical research on this topic. and the prevalence and significance of sleep disturbances in children with ADHD remains unknown.

To help understand the relationship between ADHD and sleep, we systematically reviewed the literature since 1970. We conducted a Medline search using specific search criteria and then cross-referenced these articles. We limited our search to manuscripts published in the English language in peer-reviewed journals. Based on this search, 16 studies were found that directly addressed sleep in children with ADHD in comparison to normally developing children (Busby et al., 1981; Busby and Pivik, 1985; Feinberg et al., 1974; Greenhill et al., 1983; Haig et al., 1974; Kaplan et al., 1987; Khan and Rechtschaffen, 1978; Nahas and Krynicki, 1977; Palm et al., 1992; Poitras et al., 1981; Porrino et al., 1983; Ramos Platon et al., 1990; Small et al., 1971; Stahl et al., 1979; Tirosh et al., 1993; Trommer et al., 1988). Among these 16 studies, eight studies also examined the impact of stimulant medication on sleep in children with ADHD. Also, a number of other relevant studies were reviewed: a) studies that examined the impact of stimulant medication on sleep in children with ADHD, but did not include baseline comparisons of ADHD and normal controls (Chatoor et al., 1983; Kent et al., 1995; Stein et al., 1996); b) studies in which different methodologies were employed (e.g., case study designs) (Dahl et
al., 1991; Bergman 1976); c) studies in which the focus was on sleep disordered children rather than children with ADHD (Ali et al., 1996; Hickey et al., 1992; Picchietti and Walters, 1992); and d) studies that examined pharmacological interventions for stimulant-induced sleep problems (Brown and Gammon, 1992; Prince et al., 1996). A "box-score" approach was chosen to examine the 16 studies, with the remaining studies used to provide additional information. A "box-score" approach allows for comparison across studies that differ on a number of methodological issues (e.g., definition of ADHD, inclusion and exclusion criterion, type of recording). This method was considered more appropriate than meta-analysis since many of the studies did not employ the same outcome measures (which is a necessary prerequisite for conducting a meta-analysis). It is believed that consistency in findings across studies may indicate better reliability than can be inferred from the original individual study.

The primary goal of the present review was to explore the frequency, type and significance of sleep problems in children with ADHD. Prior to reviewing this literature, we begin with a brief explanation of sleep disorders and the measurement of sleep in order to highlight pertinent issues. For a more detailed overview, see Anders and Eiben (1997), Ferber and Kryger (1995) or Stores (1996).

Sleep Disorders and Measurement Techniques

Sleep research can be divided into two general areas based on the method employed for assessing sleep problems - subjective and objective measures (Wiggs and Stores, 1995). Subjective measures (e.g., sleep diaries, questionnaires, interviews) focus on the observable aspects of sleep, such as length of sleep, time to fall asleep, number of
night awakenings, number and length of naps, etc. These measures tend to be retrospective in nature, with the exception of sleep diaries that are a daily log of sleep variables recorded by the patient and/or observer.

Objective measures of sleep (e.g., polysomnographs, actigraphy, video) typically capture information that is not observable by the human eye and are recorded in real time. Polysomnographs, which are considered the gold standard of sleep research, entail recording multiple physiological measures during sleep in a laboratory setting (Anch et al., 1988). Polysomnographs allow the researcher to examine the stages of electroencephalographic (EEG) sleep and architecture (e.g., timing and duration of non-rapid eye movement (NREM) stages and rapid eye movement (REM) sleep). Actigraphy employs the use of a small wrist watch-like computerized device that quantifies body movements during sleep. Actigraphy distinguishes between sleep and wake stages, as well as the total length of sleep, number of arousals, length of sleep onset, etc. Video recordings have also been used to objectively observe sleep behaviours. However, neither actigraphy nor video recordings allow the researcher to examine EEG sleep stages and architecture.

Methodological Issues in Sleep Research with ADHD

The majority of the studies reviewed suffer from small sample sizes (see Table 1). The two studies using subjective measures (Kaplan et al., 1987; Trommer et al., 1988) consisted of 113 children with ADHD, 65 of whom were preschoolers. This is obviously not equivalent to epidemiological data. Moreover, the number of children included in the 14 objective studies was small (91 ADHD subjects in total).
Table 1: Subject Selection Procedures for Objective Sleep Studies

<table>
<thead>
<tr>
<th>Authors</th>
<th>Subjects Characteristics</th>
<th>Type of recording</th>
<th>Medication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tirosh et al. 1993</td>
<td>3 F, 8 M</td>
<td>- actigraphy for 4 nights each: prior to medication, during medication, during placebo</td>
<td>- all children medication naive at start</td>
</tr>
<tr>
<td></td>
<td>9.8 (6.9-12.3)</td>
<td></td>
<td>- MPH 0.3 to 0.4 mg/kg once a day for 6 days (in AM) and twice a day for 2 days</td>
</tr>
<tr>
<td></td>
<td>matched on sex, age &amp;</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>socio-economic status</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Palm et al. 1992</td>
<td>2 F, 8 M</td>
<td>- polysomnographs at home for 2 nights</td>
<td>- &quot;unmedicated&quot;</td>
</tr>
<tr>
<td></td>
<td>9.3 (6.3-12.3)</td>
<td>- normal sleeping routines</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10.7 (8.8-12.6)</td>
<td>- no night for adaption</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- MSLT in lab after 2 nights of recording</td>
<td></td>
</tr>
<tr>
<td>Ramos Platon et al.1990</td>
<td>4 F, 9 M</td>
<td>- polysomnographs in lab for 2 nights</td>
<td>- medication free for at least 1 month</td>
</tr>
<tr>
<td></td>
<td>9.0 (6.9-12.1)</td>
<td>- sleep ad lib, no naps allowed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>N/A (6-12)</td>
<td>- 1st night allowed for adaption</td>
<td></td>
</tr>
<tr>
<td>Busby &amp; Pivik 1985</td>
<td>16 M</td>
<td>- polysomnograph in lab for 4 consecutive nights</td>
<td>- 8 ADHD children, no medication prior to study</td>
</tr>
<tr>
<td></td>
<td>8 M</td>
<td>- 1st night allowed for adaption</td>
<td>- 7 ADHD children on MPH</td>
</tr>
<tr>
<td></td>
<td>11.0 (1.4)</td>
<td></td>
<td>- 1 ADHD child on pemoline</td>
</tr>
<tr>
<td></td>
<td>10.4 (2.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Greenhill et al. 1983</td>
<td>9 M</td>
<td>- polysomnographs in lab for 2 nights each: baseline (after 2 week washout), follow-up (6 months from baseline)</td>
<td>- 6 months on MPH</td>
</tr>
<tr>
<td></td>
<td>7 F, 4 M</td>
<td>- no adaption night, ad lib sleep schedule</td>
<td>- given twice daily</td>
</tr>
<tr>
<td></td>
<td>8.6 (6.7-10.7)</td>
<td></td>
<td>- mean dose = 1.4 mg/kg</td>
</tr>
<tr>
<td></td>
<td>9.3 (8.3-11.8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Porrino et al. 1983</td>
<td>12 M</td>
<td>- actigraphy data was collected continuously for a 1 week period</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>12 M</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8.6 (1.9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Study</td>
<td>Gender</td>
<td>Group Size</td>
<td>Sleep Conditions</td>
</tr>
<tr>
<td>------------------</td>
<td>--------</td>
<td>------------</td>
<td>-----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Poitras et al. 1981</td>
<td>4 M</td>
<td>4 M</td>
<td>polysomnographs for 5 nights in lab</td>
</tr>
<tr>
<td>Busby et al. 1981</td>
<td>11 M</td>
<td>11 M</td>
<td>polysomnographs for 5 nights in lab</td>
</tr>
<tr>
<td>Stahl et al. 1979</td>
<td>5 N/A</td>
<td>9 N/A</td>
<td>polysomnographs for 3 or 4 nights in lab</td>
</tr>
<tr>
<td>Khan &amp; Rechtsaffen 1978</td>
<td>5 M</td>
<td>5 M, 2 F</td>
<td>polysomnographs for 3 nights in lab</td>
</tr>
<tr>
<td>Nahas &amp; Krynicki 1977</td>
<td>4 M</td>
<td>&quot;normative data&quot;</td>
<td>polysomnographs in hospital for 1 or 2 nights each</td>
</tr>
<tr>
<td>Haig et al. 1974</td>
<td>6 M</td>
<td>NC; 6 M</td>
<td>polysomnographs in lab for 5 nights</td>
</tr>
<tr>
<td>Feinberg et al. 1974</td>
<td>8 M</td>
<td>6 N/A</td>
<td>polysomnographs in lab for 4 or 5 nights</td>
</tr>
<tr>
<td>Small et al. 1971</td>
<td>3 M</td>
<td>7 N/A</td>
<td>polysomnographs as follows: 5 nights placebo, 3 nights 5 mg</td>
</tr>
</tbody>
</table>

Notes: ADHD = attention deficit hyperactivity disorder; NC = normal control group; F = females; M = males; N/A = information not available; MPH = methylphenidate; M' = multiple sleep latency test.
Diagnostic criteria and procedures varied across the studies reviewed and may account for many of the inconsistent findings. Diagnostic procedures ranged from "previously diagnosed" to employing parent and teacher interviews and rating scales. Six of the fourteen studies relied on previous diagnosis and/or did not state their diagnostic criteria. Some studies selected for children with ADHD who exhibited hyperactivity, while other studies did not make this distinction. Two of the other studies were not based on children with a diagnosis of ADHD, but employed different diagnostic criteria (Nahas and Krynicki. 1977; Palm et al., 1992). Over half of the studies did not report exclusionary criteria and most studies did not screen for comorbid disorders.

Many children included in these studies were not medication naive. In fact, only one study stipulated this as an inclusion criterion (Tirosh et al., 1993). Some studies ensured medication free periods prior to participating in the study (Greenhill et al., 1983; Nahas and Krynicki. 1977; Poitras et al., 1981; Ramos Platon et al., 1990). The type of stimulant medication varied (methylphenidate, dextroamphetamine or pemoline), as well as the dose and schedule of medication administration.

Inadequate control procedures were also characteristic of the majority of these studies. Often the comparison group was not equally matched for gender. For example, whereas the majority of the ADHD sample (90%) were male, the comparison group included a larger proportion of females. The wide range of ages may also account for inconsistencies in findings, with the ages of the children varying across the studies from six to 12 years. Even though sexual developmental stage has been previously documented to be related to sleep variables, only two studies ascertained this information (Palm et al.,
1992; Ramos Platon et al., 1990). Two studies used normative data for a comparison group that were collected in different labs, at different times, using different procedures (Nahas and Krynicki, 1977; Ramos Platon et al., 1990). Inadequate control procedures are particularly problematic in this type of research due to the changes in EEG sleep over the age span and differences between gender and prepubertal and pubertal children (Guilleminault, 1987).

The type, number and manner of assessing sleep parameters varied across studies. Variation in the measurement of these parameters makes it difficult to assess the actual differences in children with ADHD compared to normal controls across the studies reviewed. Also, there have been reservations about the use of standard polysomnographic scoring techniques when applied to children. Coble et al., (1984) compared conduct disordered (CD) children and normal controls and found no differences on standard sleep measurements, but found differences with the application of computerized automated measurement techniques (i.e., delta wave counts were higher in subjects with CD).

The days of the week on which the recordings were collected were not documented in most studies. This may have an impact on sleep as Porrino et al. (1983) found that children with ADHD had more movements during sleep on weekdays, but not on weekends. Moreover, various parameters were not controlled (e.g., differences in bedtimes on weekdays and weekends). None of the research studies examined psychosocial variables that may account for differences in sleep (e.g., bedtime routines). The influence of culture and family on sleep patterns was also not assessed in any study. For example, Sheldon (1996) documented that cultural differences in childrearing strongly influence
sleep patterns and practices (e.g., transitional objects, thumb sucking, and breast-feeding).

The use of polysomnographic techniques with children raises a number of procedural issues. The sleep lab is an unfamiliar environment and could be threatening to most children (e.g., sleeping away from home, wires being attached to the child's scalp). Sleep labs may not be set up in a manner that is comforting to a child (e.g., adjoining parent room, decorated for children). In fact, Palm et al. 1992 found that children with attention disorders tolerated procedures for sleep studies less well than normal controls (i.e., greater first-night effect). Actigraphy (Porrino et al., 1983; Tirosh et al., 1993) and home polysomnographs (Palm et al., 1992) may be more ecologically valid and may require different degrees of adaptation compared with polysomnographs conducted in the laboratory.

In sleep studies with adults, it is acceptable practice to allow at least one night to adapt to the laboratory environment. The majority of studies (13/14) that employed polysomnographs allowed for one adaptation night. However, it is not known if children require more nights for adaptation than adults.

Unlike adult sleep studies, sleep research with children needs to be particularly concerned with a number of structural variables such as allowing for naps during the day, determining when the child will be awakened, ascertaining the time the child will go to bed, and sleep arrangements (e.g., sleeping alone or with others). These structures are usually implemented by parents and may vary significantly. Changing these structures (e.g., disallowing naps, setting earlier bedtimes) may have an impact on the child's sleep. A number of studies requested that the children were not allowed to nap (Busby et al., 1981; Ramos Platon et al., 1990), whereas some studies tried to maintain regular
bedtime/sleep routines (Palm et al., 1992).

**Outcome in Sleep Research with ADHD**

*Subjective measures of sleep in children with ADHD*

Sleep disturbances have been noted to be associated with ADHD based on clinical and parental reports (Barkley, 1990). At present, there is no epidemiological evidence regarding this association. However, a few studies have examined the base rate of sleep problems in selected clinical samples of children with ADHD. Trommer et al. (1988) found that in a sample of 48 unmedicated children with ADHD, parents reported more difficulties in falling asleep (56% versus 23%) and tiredness upon waking for their children (55% versus 27%), as compared with reports from parents of 30 normal children.

Two questionnaire-based studies by Kaplan et al. (1987) showed that parents of hyperactive preschool children reported more difficulties with their child's sleep than parents of normally developing children. These results were confirmed in a third study when sleep diaries identified approximately 25 percent of children in their ADHD group who had more night awakenings, shorter daytime naps, but no difference on total sleep time or sleep onset latency compared to a normal control group.

*Objective measures of sleep in children with ADHD*

**Comparisons between ADHD and normal controls**

The fourteen studies that employed objective measures of sleep in children with ADHD are listed in Table 2. Twelve of these studies employed polysomnography and two studies employed actigraphy. Incidents of parasomnias in the ADHD population have not
Table 2: Results of Objective Sleep Studies

<table>
<thead>
<tr>
<th>Authors</th>
<th>Sleep Onset</th>
<th>Total Sleep</th>
<th>Sleep Efficiency/ Movements</th>
<th>REM sleep</th>
<th>NREM sleep</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Latency</td>
<td>Awakenings</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tirosh et al. 1993</td>
<td>ADHD=NC</td>
<td>ADHD=NC</td>
<td>ADHD&gt;NC (trend) lower</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>% quiet sleep</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Palm et al. 1992</td>
<td>ADHD&gt;NC</td>
<td>N/A</td>
<td>ADHD&lt;NC (1st night only)</td>
<td>N/A</td>
<td>ADHD=NC</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(1st night only)</td>
<td></td>
<td>ADHD=NC</td>
</tr>
<tr>
<td>Ramos Platon et al. 1990</td>
<td>ADHD&lt;NC</td>
<td>ADHD&gt;NC</td>
<td>ADHD&lt;NC (night 4 only)</td>
<td>ADHD group had less total REM, less % of sleep in REM, shorter 3rd REM period</td>
<td>Stage 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ADHD group had increased % stage 3, increased SWS, decrease</td>
<td></td>
</tr>
<tr>
<td>Busby &amp; Pivik 1985</td>
<td>ADHD&gt;NC</td>
<td>ADHD&gt;NC</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>(night 4 only)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Greenhill et al. 1983</td>
<td>ADHD=NC</td>
<td>ADHD=NC</td>
<td>ADHD=NC (weekdays only)</td>
<td>ADHD group had reduced REM activity &amp; density</td>
<td>ADHD=NC</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Porrino et al. 1983</td>
<td>N/A</td>
<td>N/A</td>
<td>ADHD&gt;NC (weekdays only)</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poitras et al. 1981</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>more spindles</td>
</tr>
</tbody>
</table>

Additional findings:

Impact of medication

- ADHD had shorter total sleep duration during MPII than baseline or placebo
- tolerated procedures less well
- no significant differences in daytime sleepiness
- ADD with hyperactivity had greater sleep fragmentation and less sleep efficiency compared to ADD without hyperactivity
- MPPI associated with delayed sleep onset, lengthened sleep and changes in REM sleep variables
- N/A
<table>
<thead>
<tr>
<th>Study</th>
<th>ADHD=NC</th>
<th>ADHD&lt;NC</th>
<th>ADHD=NC</th>
<th>ADHD&gt;NC</th>
<th>ADHD group had longer latency to 1st REM</th>
<th>ADHD group had more Stage 2, less Stage 4, less SWS in 1st cycle</th>
<th>Notes:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Busby et al. 1981</td>
<td>ADHD=NC</td>
<td>ADHD=NC</td>
<td>ADHD=NC</td>
<td>ADHD&gt;NC</td>
<td>(trend)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stahl et al. 1979</td>
<td>N/A</td>
<td>ADHD=NC</td>
<td>ADHD&lt;NC</td>
<td>N/A</td>
<td>ADHD=NC</td>
<td>ADHD=NC</td>
<td>- evidence for a 1st night effect for both groups</td>
</tr>
<tr>
<td>Khan &amp; Rechtsaffen 1978</td>
<td>N/A</td>
<td>ADHD=NC</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>ADHD group had less spindle activity</td>
<td>- growth hormone levels for ADHD group were within normal levels</td>
</tr>
<tr>
<td>Nahas &amp; Krynicki 1977</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>ADHD=NC</td>
<td>ADHD group had a decrease in REM</td>
<td>ADHD group had more Stage 2, less Stage 4, increase in sleep stage changes</td>
<td>- number of spindles doubled for subjects treated with MPH</td>
</tr>
<tr>
<td>Haig et al. 1974</td>
<td>ADHD&gt;NC</td>
<td>ADHD=NC</td>
<td>NA</td>
<td>N/A</td>
<td>ADHD group had a longer latency to 1st REM</td>
<td>ADHD=NC</td>
<td>- no drug effect</td>
</tr>
<tr>
<td>Feinberg et al. 1974</td>
<td>ADHD=NC</td>
<td>ADHD=NC</td>
<td>ADHD=NC</td>
<td>N/A</td>
<td>ADHD=NC</td>
<td>N/A</td>
<td>- no drug effect</td>
</tr>
<tr>
<td></td>
<td>ADHD&gt;NC</td>
<td>ADHD=NC</td>
<td>ADHD=NC</td>
<td>ADHD&gt;NC</td>
<td>ADHD&gt;NC</td>
<td>ADHD&gt;NC</td>
<td>- no effect of medication withdrawal</td>
</tr>
<tr>
<td>Small et al. 1971</td>
<td>ADHD&lt;NC</td>
<td>ADHD&lt;NC</td>
<td>ADHD&lt;NC</td>
<td>ADHD&gt;NC</td>
<td>ADHD&gt;NC</td>
<td>ADHD&gt;NC</td>
<td>- medication led to later onset of REM</td>
</tr>
</tbody>
</table>

**Notes:** ADHD = attention deficit hyperactivity disorder; NC = normal control group; N/A = information not available; REM = rapid eye movement; NREM = non-rapid eye movement; SWS = slow wave sleep; MPH = methylphenidate.
been systematically evaluated, and therefore only information concerning dyssomnias are presented.

Nine studies compared the sleep onset of children with ADHD with normal controls: three studies found children with ADHD to have longer latencies to sleep onset (Busby and Pivik, 1985; Haig et al., 1974; Palm et al., 1992); two studies found shorter sleep onset latencies (Ramos Platon et al., 1990; Small et al., 1971); and four studies found no differences between the groups (Busby et al., 1981; Feinberg et al., 1974; Greenhill et al., 1983; Tirosh et al., 1993). Total sleep time was measured in ten studies. Only one study found a trend between the groups, with the ADHD group having longer total sleep time (Ramos Platon et al., 1990). The remaining nine studies found no differences between the ADHD and normal control groups (Busby et al., 1981; Busby and Pivik, 1985; Feinberg et al., 1974; Greenhill et al., 1983; Haig et al., 1974; Khan and Rechtschaffen, 1978; Small et al. 1971; Stahl et al., 1979; Tirosh et al., 1993). Sleep efficiency (relative proportion of time in bed to time asleep) was addressed in eight studies. None of the studies found that the ADHD group had better sleep efficiency than normal subjects. Three studies found worse sleep efficiency (Palm et al., 1992; Ramos Platon et al., 1990; Stahl et al., 1979), whereas five studies did not find any differences (Busby et al., 1981; Feinberg et al., 1974; Greenhill et al., 1983; Small et al., 1971; Tirosh et al., 1993).

Movements during sleep were measured in six studies, two of which used actigraphy (Porrino et al., 1983; Tirosh et al., 1993), and the remaining four studies used polysomnographs (Busby et al., 1981; Greenhill et al., 1983; Nahas and Krynicki, 1977; Small et al., 1971). Four of these studies found that ADHD subjects evidenced more
movements in sleep than a normal control group (Busby et al., 1981; Porrino et al., 1983; Small et al., 1971; Tirosh et al., 1993). Two studies found no difference in the number of movements between the two groups (Greenhill et al., 1983; Nahas and Krynicki, 1977). Only one study examined sleepiness in ADHD subjects through the use of the Multiple Sleep Latency Test. Palm et al. (1992) did not find any statistically significant differences between the two groups in the time to fall asleep in the sequence of daytime naps, however. More children with ADHD were "sleepy" (i.e., three ADHD subjects had very short sleep onset latencies). The experimental group had been diagnosed with "deficits in attention, motor control and perception" (DAMP), which is similar in many ways to ADHD, but also has some significant differences (e.g., focus on motor and perceptual difficulties and not restlessness and impulsivity).

Sleep architecture parameters that have been investigated in the ADHD population include: amount and density of REM; latency to the onset of REM; and percentage of total sleep time in various sleep stages. REM sleep was examined in nine studies and NREM sleep was examined in ten studies. Differences in REM sleep were found between ADHD and normal controls in five of the nine studies (Busby et al., 1981; Greenhill et al., 1983; Haig et al., 1974; Nahas and Krynicki, 1977; Ramos Platon et al., 1990). Three of these studies reported reduced amount of REM sleep in the ADHD group. Ramos Platon et al. (1990) found that reduced REM was associated with the hyperactivity component of ADHD rather than the inattention component, and interpreted this finding as relating to the instability of sleep in children with ADHD. The other two studies reported a longer latency to the first REM period in the ADHD group. A similar pattern of inconsistencies
was found when NREM was examined. Two studies were specifically designed to measure EEG sleep spindle activity (13-15 Hz) which are thought to be an index of motor inhibition. One study found a reduced number of spindles (Khan et al., 1978), whereas the other study found an increase in the number of spindles (Poitras et al., 1981). An additional eight studies examined other aspects of NREM sleep. Five of these studies found no differences (Greenhill et al., 1983; Haig et al., 1974; Palm et al., 1992; Small et al., 1971; Stahl et al., 1979). Two studies found increases in Stage 2 sleep (Busby et al., 1981; Nahas and Krynicki, 1977) and one study found an increase in Stage 3 for the ADHD group (Ramos Platon et al., 1990).

**Stimulant effects on sleep**

Eight of the 14 studies employing objective measures also examined the impact of stimulant medication (primarily methylphenidate) on children with ADHD. Two studies found no differences between the no medication and medication conditions (Haig et al., 1974; Nahas and Krynicki, 1977). The remaining six studies did find some differences, although these differences were not considered to be in the pathological range (Busby and Pivik, 1985; Feinberg et al., 1974; Greenhill et al., 1983; Khan and Rechtschaffen, 1978; Small et al., 1971; Tirosh et al., 1993). In the study by Khan and Rechtschaffen (1978), the number of spindles doubled after administration of methylphenidate. In a study exploring awakening to auditory stimuli (Busby and Pivik, 1985), it was found that non-medicated children with ADHD were more easy to arouse than medicated ADHD subjects. This finding was interpreted as potential support for a hyperarousal theory of ADHD. Reduced latency of sleep onset was noted in one study (Tirosh et al., 1993), whereas prolonged sleep
onset was found in another study (Small et al., 1971). Three studies noted some change in REM sleep. Greenhill et al. (1983) found increased number of REM periods, as well as increased REM activity and fragmentation. The other two studies found a later onset to the first REM period (Feinberg et al., 1974; Small et al., 1971).

The literature search revealed three additional studies that addressed the impact of stimulants on sleep in children with ADHD, however, these did not include baseline comparison with normal controls. Two studies compared the impact of BID (two doses a day) and TID (three doses a day) medication schedules on sleep in children with ADHD. Kent et al. (1995) found that a third dose of medication did not change sleep onset (based on nurses' ratings), but did affect level of tiredness upon waking (i.e., children on a TID schedule were rated as more tired). Based on both parent ratings and actigraphy, Stein et al. (1996) found that a TID schedule did not affect sleep duration more than a BID schedule. However, there was a trend toward a reduction in total sleep time on the TID schedule. Chatoor et al. (1983) examined the effect of a nocturnally administered dose of stimulant medication. They found significant changes in sleep architecture (e.g., delay in first REM period, and a decreased percentage of REM sleep).

**Intervention research focused on sleep and ADHD**

The literature search revealed two published case studies of children with ADHD and a sleep disorder. In a case study by Dahl et al. (1991), a 10 year old girl with ADHD and delayed sleep phase insomnia was treated with a combination of behavioural modification and chronotherapy (successively delay sleep times around the clock until sleep onset realigns with an earlier clock time) for her sleep disorder. This intervention
resulted in significant improvements in sleep behaviours as well as daytime behaviours (e.g., improved peer interactions, increased productivity in arithmetic tasks and more completion of seat work). These gains were maintained over the four month follow-up period based on teacher ratings and classroom performance. Another case study by Bergman (1976) reported a behavioural intervention targeted at insomnia in a seven year old boy diagnosed with ADHD. Elimination of sleep difficulties was obtained as well as marked reduction in hyperactivity and these affects were still evident at follow-up six months later.

The overlap between a diagnosis of sleep disorders and ADHD has led to a number of case studies in which "misdiagnosis" of ADHD in sleep disordered children have been reported. For example, Hickey et al. (1992) reported three children with restless leg syndrome who had been misdiagnosed as ADHD. Picchietti and Walters (1994) found that 34 percent of children seen for ADHD had sufficient symptoms of periodic leg movement disorder (PLMD) to warrant a sleep investigation. Of these children referred for a sleep study, 14 had sufficient symptoms to make a diagnosis of PLMD. This works out to be 20 percent of the original sample. Treatment for PLMD (clonidine or levodopa/carbidopa) proved successful in treating both the nighttime and daytime behavioural difficulties of these children.

A recent study by Ali et al. (1996) compared children with and without sleep disorders who were on the waiting list for adenotonsillectomy. After the surgical procedure, the sleep disordered group displayed significant improvements in ratings of aggression, inattention and hyperactivity based on parent's ratings. They also demonstrated
improvements on a computerized measure of sustained attention.

Pharmacological interventions for stimulant induced sleep disturbances have recently been explored. In an open study of 18 stimulant treated children with ADHD, Brown and Gammon (1992) found that clonidine (an \( \alpha \)-adrenergic agonist) was effective in reducing sleep onset difficulties. Prince et al. (1996) conducted a retrospective study of 62 children/adolescents with ADHD who had been placed on clonidine for sleep problems. Sleep problems that were induced or exacerbated by medication, as well as pre-existing sleep problems, all responded well to the introduction of clonidine (85% of patients demonstrated marked improvements).

**Box-score Interpretation**

Parents of children with ADHD more often report a variety of sleep problems than do parents of normal controls (Kaplan et al., 1987; Trommer et al., 1988). An estimate of the prevalence of sleep problems based on these two samples of children with ADHD (total sample of 113) is between 25 and 50 percent, compared with 7 percent of normal controls. This represents approximately a five-fold increase in the rate of sleep problems in children with ADHD. Given this finding, it is unlikely that the relationship between ADHD and sleep problems is spurious. Based on the current research literature it is impossible to determine if increased parental reports of sleep problems in ADHD are unique to a diagnosis of ADHD or if they reflect general psychological disturbances. No study has compared sleep disturbances in children with ADHD to other pathological comparison groups, nor has any study examined the contribution of psychosocial factors to the development and maintenance of sleep problems in this population.
The results of the studies that employed objective measures of sleep were often inconsistent. In eight of the studies that assessed sleep onset latency, it was found to be longer (33%), shorter (22%) and the same (45%). A fairly consistent result was evident across studies for total sleep time, with 90 percent of the studies (9 out of 10 studies) finding no difference between ADHD and normal controls. Sleep efficiency was significantly less for the ADHD group in 38% of the studies (3 out of 7 studies) and did not differ in the remaining studies. Sixty-seven percent of the studies (4 out of 6) found that the ADHD group displayed more movements during sleep. An equal number of studies found differences between the ADHD group and normal control group in REM and NREM sleep as those that did not find differences (REM and NREM: 55% and 50% found differences, respectively).

Since sample sizes were very small, the inconsistent findings may reflect Type II errors, or may reflect inadequate and inconsistently applied diagnostic criteria for ADHD. Only two relatively consistent findings across the studies were found. First, the ADHD group did not differ from the normal control group on total sleep time (90% of studies found no difference). This finding is also consistent with the studies that employed subjective measures. Second, children with ADHD were found to be more restless during sleep (67%). Actigraphy seemed more sensitive to these differences than polysomnographic readings, with both of the studies employing actigraphy finding differences compared to half of the studies that employed polysomnographs.

Changes in various sleep parameters with the introduction of stimulant medication were noted in 75 percent of the studies (6 out of 8). Typically, stimulant medication
prolonged sleep latency and onset to first REM cycle, however, these changes were not considered to place the child in the "pathological" range indicative of a serious sleep disorder. Control procedures make interpretation of this finding difficult given that children were on different medications, different doses and different administration schedules. Also, many of the children were not medication naive and went through varying lengths of "wash out" periods prior to participating in the sleep studies.

Clinical Implications

Clinically it would appear prudent to assess children with ADHD for sleep disturbances. Sleep problems in children have been reported as a significant stressor for parents (Saxby and Morgan, 1995), yet they are rarely mentioned in clinical interviews. Anecdotal reports suggest that treatment for specific sleep problems improves attention and hyperactivity, as well as family functioning and reduce stress levels. Even though the reason and nature of sleep disturbances in ADHD remains unknown, behavioural treatment of these difficulties may provide symptom relief for children with ADHD and improvement in their family relationships.

Conclusions

The present review highlights the importance of future investigations of the relationship between ADHD and sleep disorders. Future studies should: 1) provide precise characterization of the type, severity, frequency and significance of sleep problems in children who have a confirmed diagnosis of ADHD; 2) compare sleep parameters of children with ADHD with both non-disabled children and other children with behaviour problems, learning disabilities and sleep disturbances; 3) explore the impact of comorbid
disorders (e.g., anxiety) on the presentation of sleep disturbances in children with ADHD; and 4) determine the reason for the apparent contradictory findings between studies employing subjective and objective methodologies (for a discussion of this issue see Ball and Koloian, 1995). Finally, the inference that stimulant medication does not have a detrimental impact on sleep in children with ADHD (Ball and Koloian, 1995) should be reviewed further given recent findings that sleep problems persist with extended treatment of ADHD with stimulant medication (Schachar et al., 1996).
CHAPTER 3

Sleep problems in children with attention-deficit/hyperactivity disorder: Impact of subtype, comorbidity and stimulant medication


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ABSTRACT

Objective: To determine the relationship of sleep problems to ADHD, diagnostic subtype, comorbid disorders and the effects of stimulant treatment.

Method: Based on clinical diagnostic interviews, children aged 6 to 12 years were assigned to four groups: unmedicated ADHD (n = 79); medicated ADHD (n = 22); clinical comparison (n = 35); and healthy non-clinical comparison (n = 36). These groups were compared on two sleep questionnaires completed by the parents that assessed current sleep problems and factors associated with sleep difficulties (i.e., sleep routines, sleep practices, child and family sleep history).

Results: Factor analysis revealed three sleep problem categories: dyssomnias, parasomnias and sleep-related involuntary movements. Linear regression analyses showed that: 1) dyssomnias were related to confounding factors (i.e., comorbid opposition defiant disorder and stimulant medication) rather than ADHD; 2) parasomnias were similar between clinical and non-clinical children; and 3) the DSM-IV combined subtype of ADHD was associated with sleep-related involuntary movements. However, sleep-related involuntary movements were more highly associated with separation anxiety.

Conclusions: The results suggest that the relationship between sleep problems and ADHD is complex and depends on the type of sleep problem assessed as well as confounding factors such as comorbid clinical disorders and treatment with stimulant medication.
Attention-Deficit/Hyperactivity Disorder (ADHD) is the most common problem presented to children's mental health services and occurs in approximately five percent of school-aged children (American Psychiatric Association, 1994). In addition to the core symptomatology (i.e., inattention, impulsiveness and restlessness), ADHD is associated with other problems (e.g., sleep disturbances, academic underachievement, poor social relations) and shows a high rate of comorbidity with other clinical disorders (e.g., anxiety. depression, oppositional defiant disorder) (Barkley, 1990). Problems with sleep are included on several popular child rating scales used as part of the diagnostic procedures for ADHD (e.g., Conners Rating Scales; Conners, 1997). Nevertheless, sleep problems are not included in the current diagnostic criteria (i.e., DSM-IV), even though excessive movements during sleep had been included in a previous version (DSM-III). Despite clinical observations of sleep problems in children with ADHD, there is little empirical research on this topic. The prevalence, type of sleep problems and significance of these sleep disturbances in children with ADHD remains undocumented (Corkum et al., 1998).

A recent review of the research that examined sleep disturbances in children with ADHD (Corkum et al., 1998) indicated that the majority of studies suffer from small sample sizes, inconsistent diagnostic criteria and procedures, inadequate control procedures and unclear medication status. It was also found that results differed based on the methodology employed to assess sleep problems, with sleep problems frequently found on subjective measures (e.g., questionnaires) but few found on objective measures (e.g., polysomnographs). At the time of the review, no study had examined sleep disturbances in children with ADHD compared to other clinical groups, and to date only one study
examined the contribution of comorbid clinical disorders to sleep problems in children with ADHD (Marcotte et al., 1998). The failure to include clinical comparison groups is surprising, as many of the psychiatric disorders that often co-exist with ADHD (e.g., conduct disorders, anxiety disorders, depression) have also been associated with sleep problems (for a review see Stores, 1996). Moreover, no study has explored the contribution of the different DSM-IV subtypes of ADHD, even though one study found that the various symptoms of ADHD (i.e., inattention and hyperactivity) were important in understanding the relationship between sleep and ADHD (Ramos Platon et al., 1990).

Sleep disorders in children are not a unitary clinical problem and are commonly classified in the following groups: 1) dyssomnias (e.g., insomnia, circadian rhythm sleep disorders); 2) sleep-related involuntary movements (e.g., bruxism, periodic limb movement disorder, sleep talking); 3) sleep-related breathing disorders (e.g., obstructive sleep apnea); and 4) non-rapid eye movement (NREM) parasomnias (e.g., sleepwalking, sleep terrors). (For a comprehensive review of pediatric sleep disorders see Anders and Eiben, 1997.) Most of the sleep research in ADHD has focused on dyssomnias and sleep-related involuntary movements (see Corkum et al., 1998 for a review). A few studies have addressed sleep-related breathing disorders (e.g., Ali et al., 1996), but there has been no empirical research examining NREM parasomnias in children with ADHD. Although there exists clinical and experimental evidence that suggests children with ADHD may suffer from a wide range of sleep problems, the results of the research have been inconclusive.

Four models are proposed to explain the relationship between ADHD and sleep
disturbances. Firstly, it may be that specific sleep problems are uniquely related to the
diagnostic category of ADHD. Secondly, sleep problems may be related to another
disorder that often co-occurs with ADHD (e.g., anxiety). Thirdly, sleep problems may be
the result of stimulant medication that is commonly used to treat ADHD. Finally, it may
be that sleep problems are not related to ADHD, but rather these problems are common in
the general population of latency-aged children.

To clarify the relationship between sleep problems and ADHD, the present study
compares four groups of children: 1) a group of children with ADHD not on stimulant
medication (unmedicated ADHD); 2) a group of children with ADHD currently taking
stimulant medication (medicated ADHD); 3) a group of children referred for a clinical
assessment who did not reach diagnostic criteria for ADHD, but who exhibited other
psychopathology (clinical comparison group); and 4) a group of healthy children recruited
as a normal comparison group (non-clinical comparison group). The specific goals of this
study were to: 1) compare these groups on factors associated with sleep problems (e.g.,
sleep practices, bed and wake times, history of sleep problems in the child and immediate
family); 2) examine their base rates on a wide range of sleep disturbances; and 3) explore
the relationship between current sleep problems and ADHD. These specific goals should
help determine if specific sleep problems are related to ADHD, to stimulant medication
use, and/or comorbid conditions. This study is unique in that it employed rigorous
diagnostic procedures, assessed a wide range of sleep problems and included DSM-IV
subtypes for ADHD. The study also included ADHD children with and without
medication, as well as non-clinical and clinical comparison groups.
METHOD

Subjects

The current sample consisted of 172 children and families, 136 of whom were referred to a child psychiatry clinic for problems with attention, behaviour and learning (NIH Grant #HD31714) and 36 who were recruited through community advertisements as a non-clinical comparison group. All the children included in this study were between the ages of 6.10 years and 12.3 years of age (mean age = 9.1 years). There were a total of 140 males and 32 females. Children were excluded if they had a Verbal IQ and Performance IQ of less than 80, brain injury, pervasive developmental disorder, autism, psychosis, post-traumatic stress disorder or if they were suffering from a primary anxiety or affective disorder.

Diagnostic Measures

A rigorous clinical diagnostic assessment was conducted for each subject, including the non-clinical comparison group. Diagnostic evaluation consisted of a face-to-face parent interview, a telephone interview with the child's teacher, and a comprehensive child assessment. The parent interview (Parent Interview for Child Symptoms-DSM-IV {PICS-IV}; Schachar et al., unpublished manuscript) covers the child's development and current behaviour and includes all the DSM-IV diagnostic criteria for externalizing and internalizing disorders of childhood. The teacher interview (The Telephone Teacher Interview-DSM-IV {TTI-IV}; Tannock and Schachar, unpublished manuscript) follows the same basic format as the PICS-IV, but focuses on three diagnostic areas in detail (ADHD, oppositional defiant disorder {ODD} and conduct disorder {CD}) and screens for
internalizing disorders (i.e., generalized anxiety disorder {GAD}, separation anxiety disorder {SAD}, and depression {DEP}). The PICS-IV and TTI-IV were administered by trained clinicians (i.e., psychometrists, social workers and psychiatrists) who rated the behaviour on a four-point scale of severity and frequency based on elicited descriptions of behaviour. These semi-structured interviews have been demonstrated to be reliable measures for use in diagnosing child psychopathology based on the DSM-III-R (Schachar et al., 1995), and reliability estimates for DSM-IV are in progress. In addition to the diagnostic interviews, parents and teachers completed rating scales and questionnaires to provide supportive information.

The child assessment consisted of measures of cognitive processing, academic achievement and psychosocial functioning. Among these measures were the Wechsler Intelligence Scale for Children-Third Edition (WISC III; Wechsler, 1991) and the reading and arithmetic subtests of the Wide Range Achievement Test-Third edition (WRAT-3; Wilkinson, 1993). A learning disability (LD) was defined by a standard score of at least 1.5 standard deviations below the age mean on either the WRAT-3 reading or arithmetic subtest. Given the most recent practice parameters for diagnosing LD, an IQ-achievement discrepancy score was not employed (Fletcher et al., 1998).

**Diagnostic Groups**

Of the 136 children referred to the assessment and treatment program for suspected ADHD, 101 reached criteria for ADHD. Of these 101 children, 79 were not currently on medication and 22 were taking medication (with the exception of a 24 hour withdrawal prior to the assessment). Of the 22 children taking stimulant medication, 20 were taking
methylphenidate (14 short-acting and 6 slow-release) and 2 were taking Dextro-amphetamine (both slow-release). The dosing schedule for all subjects was either once or twice daily, for an average duration of one year. The remaining 35 children were considered sub-threshold for ADHD, however many reached criteria for ADHD in one setting (i.e., 8 children reached criteria in the school setting only and 11 children in the home setting only). The majority of the 35 subjects (77 percent) reached diagnostic criteria for one or more psychiatric disorders. Children recruited from the assessment and treatment program were grouped into three clinical groups: unmedicated ADHD (N = 79); medicated ADHD (N = 22); and clinical comparison group (N = 35). A non-clinical comparison group (N = 36) was recruited through community advertisements for children without behavioural, emotional or learning difficulties.

Subject Characteristics

The subjects' age, IQ and gender as well as the percentage of children in each group who reached criteria for the various subtypes of ADHD and other disorders is presented in Table 1. The four groups did not differ on their mean age or gender distribution. As typically found, the non-clinical comparison group and clinical groups differed on IQ. More specifically, the mean IQ of the non-clinical comparison group was at the high end of the Average range, whereas the mean IQ of the clinical groups was in middle of the Average range. Also, as shown in Table 1, children in the clinical groups were more likely to have comorbid LD.

Because the DSM-IV does not specify an algorithm for pervasiveness or combining information across informants, this study employed a "6/4" algorithm to classify ADHD
Table 1: Subject Characteristics, ADHD subtypes and comorbid diagnoses

<table>
<thead>
<tr>
<th></th>
<th>Non-clinical Comparison Group N = 36</th>
<th>Unmedicated ADHD Group N = 79</th>
<th>Medicated ADHD Group N = 22</th>
<th>Clinical Comparison Group N = 35</th>
<th>X² value/ F-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>age (years.months)</td>
<td>9.4 (1.40)</td>
<td>9.2 (1.49)</td>
<td>8.7 (1.56)</td>
<td>8.10 (1.26)</td>
<td>1.32</td>
</tr>
<tr>
<td>IQ</td>
<td>114.3 (15.0)</td>
<td>100.0 (13.6)</td>
<td>97.3 (12.3)</td>
<td>97.7 (14.2)</td>
<td>11.64*</td>
</tr>
<tr>
<td>sex (% males)</td>
<td>77.8</td>
<td>82.3</td>
<td>86.4</td>
<td>80.0</td>
<td>0.76</td>
</tr>
<tr>
<td>LD (% diagnosed)</td>
<td>2.8</td>
<td>27.8</td>
<td>27.3</td>
<td>34.3</td>
<td>11.74*</td>
</tr>
<tr>
<td>ADHD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>inattention</td>
<td>0 (0.0)</td>
<td>25 (31.6)</td>
<td>6 (27.3)</td>
<td>0 (0.0)</td>
<td>26.81*</td>
</tr>
<tr>
<td>hyp-imp</td>
<td>0 (0.0)</td>
<td>14 (17.7)</td>
<td>7 (31.8)</td>
<td>0 (0.0)</td>
<td>20.01*</td>
</tr>
<tr>
<td>combined</td>
<td>0 (0.0)</td>
<td>40 (50.6)</td>
<td>9 (40.9)</td>
<td>0 (0.0)</td>
<td>48.97*</td>
</tr>
<tr>
<td>ODD</td>
<td>4 (11.1)</td>
<td>33 (41.8)</td>
<td>9 (40.9)</td>
<td>13 (37.1)</td>
<td>11.10*</td>
</tr>
<tr>
<td>CD</td>
<td>1 (2.8)</td>
<td>20 (25.3)</td>
<td>5 (22.7)</td>
<td>5 (14.3)</td>
<td>9.17*</td>
</tr>
<tr>
<td>GAD</td>
<td>1 (2.8)</td>
<td>11 (13.9)</td>
<td>8 (36.4)</td>
<td>7 (20.0)</td>
<td>12.32*</td>
</tr>
<tr>
<td>SAD</td>
<td>1 (2.8)</td>
<td>12 (15.2)</td>
<td>4 (18.2)</td>
<td>5 (14.3)</td>
<td>4.29</td>
</tr>
<tr>
<td>DEP</td>
<td>0 (0.0)</td>
<td>7 (8.9)</td>
<td>2 (9.1)</td>
<td>4 (11.4)</td>
<td>3.96</td>
</tr>
<tr>
<td># of diagnosis</td>
<td>0.19 (0.40)</td>
<td>1.97 (0.78)</td>
<td>2.18 (1.01)</td>
<td>0.83 (0.82)</td>
<td>59.12*</td>
</tr>
</tbody>
</table>

* significant at p < .05

Notes: For diagnostic categories, the first value represents the number of children who reached criteria and the number in parentheses represents the group percentage. IQ = intelligence quotient; LD = learning disabled; ADHD = attention-deficit/hyperactivity disorder; inattention = inattention subtype; hyp-imp = hyperactivity-impulsivity subtype, combined = combined subtype; ODD = oppositional defiant disorder; CD = conduct disorder, GAD = generalized anxiety disorder, SAD = separation anxiety disorder, DEP = major depressive episode.
subtypes. For this algorithm, the two interviews are given equal weight. To meet
diagnostic criteria of ADHD, the child had to exhibit a minimum of four symptoms in at
least one cluster (i.e., inattention or hyperactivity-impulsivity) on both interviews, plus
must meet at least six symptoms of inattention or hyperactivity-impulsivity on one of the
two interviews. For example, the combined subtype required at least six symptoms of
inattention and six symptoms of hyperactivity-impulsivity, plus evidence of pervasiveness
(i.e., at least four symptoms in one of the areas on the other interview). Based on this
algorithm, none of the children in the non-clinical or the clinical comparison groups
reached criteria for any subtype of ADHD. For both the unmedicated and medicated
ADHD groups, the most common subtype of ADHD was the combined subtype. A
diagnosis of ODD and/or CD was given if the child reached diagnostic criteria for the
disorder on either the parent and/or teacher interview. Diagnoses of internalizing disorders
were given if the child reached diagnostic criteria on the parent interview and/or was given
a rating of "marked abnormality" on the screen included on the teacher interview. The
groups differed on both externalizing disorders (i.e., ODD and CD) and GAD, with the
clinical groups having more children with these diagnoses. Although similar differences
were noted between the clinical groups and non-clinical comparison group for SAD and
DEP, these did not reach significance (see Table 1).

Measures

The Child Sleep Questionnaire - Parent Version

The Child Sleep Questionnaire - Parent Version (CSQ-P; Blader et al., 1997)
provides an assessment of sleep problems and sleep-related issues for elementary school-
aged children. It was used previously in a community sample of 972 children between the ages of 5 to 12 years (Blader et al., 1997). The CSQ-P employs a predominantly multiple-choice format and assesses sleep routines, sleep practices, and current sleep problems over the past six months. The questionnaire is divided into four sections that focus on: 1) initial sleep; 2) middle sleep; 3) sleep termination; and 4) sleep-related issues (e.g., assessment/treatment for sleep problems). The parent most familiar with the child's sleep completed the CSQ-P during the initial diagnostic assessment. After completing the questionnaire, a research assistant scanned the questionnaire for missing data and the parent was asked to complete any missing information. A number of new indexes were developed based on the information obtained from the CSQ-P.

Sleep Routines. This index was comprised of questions about the child's typical bedtime and wake time for both weekdays and weekends. The child's total sleep time on weekdays and weekends was calculated from this information.

Sleep practices. An index measuring the total number of "poor" sleep practices was calculated. This index included the following items: 1) irregular bedtime; 2) sharing a bed; 3) falling asleep outside their own bed; 4) requiring a light on; 5) requiring the door to be open; 6) going to parents' bed or parent to child's bed during night; and 7) having a fixed non-compromising settling routine. Each of these "poor" sleep practices had been found to be related to sleep problems in an epidemiological study (Blader et al., 1997).

Current Sleep Problems. Fourteen questions from the CSQ-P addressed specific sleep disturbances (i.e., bedtime resistance, sleep onset difficulties, night waking, nightmares, sleep terrors, enuresis, sleep talking, sleep walking, snoring, teeth grinding,
jerky leg movements during sleep, restlessness, and difficulties arising on weekdays and weekends). Seven of these items were rated on a six point scale, three items were rated on a five point scale and four items were rated on a two point scale (i.e., yes/no).

**Child and Family Sleep History Questionnaire**

In the absence of any relevant questionnaires that measure sleep history for elementary school children and their family members, a questionnaire was developed by the first author. The Child and Family Sleep History Questionnaire (CFSH) assessed sleep problems during infancy (birth to one year) and during the preschool years (one to four years of age), as well as the immediate family's history of sleep problems. (A copy of the questionnaire can be obtained by contacting the author.) Two indices were computed from this questionnaire.

*History of Sleep Problems.* The questionnaire listed eight common sleep problems that can occur during infancy and the preschool years (e.g., trouble settling, restless sleep). The parent was asked to reflect upon their child's sleep during these years and to check as many boxes as applied in each of the indicated age groupings. The final index was comprised of the total number of positive responses across both the infancy and preschool questions (i.e., scores ranging from 0 to 16).

*Family history of sleep problems.* The questionnaire asked that the respondent identify sleep difficulties in 18 specified areas (e.g., trouble falling asleep, excessive daytime sleepiness) for each parent and sibling. For calculation of the index score, each of the 18 questions were scored positive if a parent and/or sibling had experienced the sleep problem. The index was comprised of the total number of positive responses.
Analysis

The results of the study are presented in three sections: 1) factors associated with sleep problems; 2) current sleep problems; and 3) prediction of current sleep problems. The Statistical Package for Social Sciences was used for all analyses. The first set of analyses compare the sleep practices, sleep routines and sleep history of the child and immediate family across the four groups. One-way analysis of variance was used for all tests and Newman-Keuls post hoc analyses were used for significant findings.

The second set of analyses included a principal component analysis with varimax rotation that was conducted in order to reduce the total number of variables addressing current sleep problems. Using one-way analysis of variance and Newman-Keuls post hoc analyses, the groups were then compared on the factors derived from the factor analysis.

The final set of analyses used hierarchical linear regressions to explore the relationship between current sleep problems and ADHD subtype, comorbid diagnoses, and stimulant medication. Regressions were conducted for each factor identified in the preceding set of analyses in which significant group differences were found. In the first step, two covariates were entered (age and sex). In the second step, the three subtypes of ADHD (i.e., inattention, hyperactivity-impulsivity and combined) were entered using a stepwise method to assess the relationship between ADHD subtypes and sleep problems while controlling for the covariates. The third step employed a stepwise method in which comorbid diagnoses and stimulant medication were entered (i.e., ODD, CD, GAD, SAD DEP, LD and medication) to determine whether confounds between the relationship of ADHD and sleep disturbances exist (i.e., whether it is the comorbidity or medication rather
than ADHD that is more strongly associated with sleep disturbances).

RESULTS

Factors Associated with Sleep Problems

Parental report of sleep routines and practices (CSQ-P), as well as the child and family sleep histories (CFSH) of the four groups can be found in Table 2. Examination of sleep routines found that the average total sleep time for all four groups was between 10 and 10 ½ hours. None of the groups differed in terms of the average bedtime, wake time, or total sleep duration for weekends. However, a difference was found between the groups on weekday wake time and total sleep time, with the unmedicated ADHD group having a longer total sleep time on weekdays compared to the non-clinical group. This group averaged approximately 15 minutes of additional bedtime on weekdays. For sleep practices, the three clinical groups had poorer sleep practices compared to the non-clinical comparison group.

Compared to the non-clinical group, parents in all three clinical groups endorsed approximately a two-fold increase in the incidence of sleep problems over the course of their child’s development. Parents in the unmedicated ADHD group and the clinical comparison groups indicated twice the rate of sleep problems in the child's immediate family. The medicated ADHD group did not differ from either the non-clinical comparison group or the other two clinical groups.

Current Sleep Problems

Results from the Factor Analysis can be found in Table 3. Initially, all 14 items relating to sleep problems on the CSQ-P were included in the analysis, however, three
Table 2: Factors associated with sleep problems

<table>
<thead>
<tr>
<th></th>
<th>Non-clinical Comparison</th>
<th>Unmedicated ADHD</th>
<th>Medicated ADHD</th>
<th>Clinical Comparison</th>
<th>F-value</th>
<th>Newman-Keuls Post-hoc tests</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Group (0)</td>
<td>Group (1)</td>
<td>Group (2)</td>
<td>Group (3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>N = 36</td>
<td>N = 79</td>
<td>N = 22</td>
<td>N = 35</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Weekdays**

<table>
<thead>
<tr>
<th></th>
<th>PM (8-10)</th>
<th>AM (7:30-10)</th>
<th>PM (7-8)</th>
<th>AM (6-8:30)</th>
<th>PM (8.30-11)</th>
<th>AM (6-11)</th>
<th>PM (8-11.5)</th>
<th>AM (8-12)</th>
<th>PM (8-13)</th>
<th>AM (8-12)</th>
<th>PM (8-13)</th>
<th>AM (8-12)</th>
</tr>
</thead>
<tbody>
<tr>
<td>wake time AM</td>
<td>7:07</td>
<td>7:17</td>
<td>7:04</td>
<td></td>
<td>7:04</td>
<td>7:17</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>total time</td>
<td>10 h 15m</td>
<td>10 h 31m</td>
<td>10 h 30m</td>
<td>10 h 12m</td>
<td>10 h 31m</td>
<td>10 h 30m</td>
<td>10 h 30m</td>
<td>10 h 12m</td>
<td>10 h 13m</td>
<td>10 h 18m</td>
<td>10 h 04m</td>
<td>10 h 18m</td>
</tr>
</tbody>
</table>

**Weekends**

<table>
<thead>
<tr>
<th></th>
<th>PM (8:30-11)</th>
<th>AM (7:30-12)</th>
<th>PM (8-11)</th>
<th>AM (6-8)</th>
<th>PM (8.30-11.5)</th>
<th>AM (8-12.5)</th>
<th>PM (8-13)</th>
<th>AM (8-12)</th>
</tr>
</thead>
<tbody>
<tr>
<td>wake time AM</td>
<td>7:44</td>
<td>8:03</td>
<td>7:41</td>
<td>7:51</td>
<td>7:44</td>
<td>8:03</td>
<td>7:41</td>
<td>7:51</td>
</tr>
<tr>
<td>total time</td>
<td>10h 06m</td>
<td>10h 13m</td>
<td>10h 18m</td>
<td>10h 04m</td>
<td>10h 06m</td>
<td>10h 13m</td>
<td>10h 18m</td>
<td>10h 04m</td>
</tr>
</tbody>
</table>

| Sleep practices     | 0.95 (1.04)  | 1.76 (1.21)  | 2.32 (1.25) | 1.97 (1.40) | 0.95 (1.04)   | 1.76 (1.21)  | 2.32 (1.25) | 1.97 (1.40) |
| Child history       | 0.86 (1.61)  | 2.35 (2.97)  | 2.68 (2.21) | 2.31 (2.41) | 0.86 (1.61)   | 2.35 (2.97)  | 2.68 (2.21) | 2.31 (2.41) |
| Family history      | 2.64 (2.68)  | 4.82 (3.99)  | 3.45 (3.35) | 4.97 (4.23) | 2.64 (2.68)   | 4.82 (3.99)  | 3.45 (3.35) | 4.97 (4.23) |

* significant at p < .05

Notes: Values in parentheses for weekday and weekend sleep times represent ranges and for sleep practices and history represent standard deviations. h = hours, m = minutes.
Table 3: Rotated factor matrix

<table>
<thead>
<tr>
<th></th>
<th>Factor 1 (Dyssomnias)</th>
<th>Factor 2 (Involuntary movements)</th>
<th>Factor 3 (Parasomnias)</th>
</tr>
</thead>
<tbody>
<tr>
<td>difficulties arising -</td>
<td>.73</td>
<td>.06</td>
<td>.01</td>
</tr>
<tr>
<td>weekdays</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>difficulty arising -</td>
<td>.71</td>
<td>.06</td>
<td>-.07</td>
</tr>
<tr>
<td>weekends</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>bedtime resistance</td>
<td>.70</td>
<td>.18</td>
<td>-.13</td>
</tr>
<tr>
<td>sleep onset</td>
<td>.61</td>
<td>.25</td>
<td>.15</td>
</tr>
<tr>
<td>sleep talking</td>
<td>.01</td>
<td>.72</td>
<td>.11</td>
</tr>
<tr>
<td>restless sleep</td>
<td>.37</td>
<td>.63</td>
<td>.08</td>
</tr>
<tr>
<td>jerky movements</td>
<td>.14</td>
<td>.59</td>
<td>.05</td>
</tr>
<tr>
<td>during sleep</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>teeth grinding</td>
<td>-.08</td>
<td>.68</td>
<td>.04</td>
</tr>
<tr>
<td>sleep terrors</td>
<td>-.03</td>
<td>.06</td>
<td>.81</td>
</tr>
<tr>
<td>sleep walking</td>
<td>-.03</td>
<td>.06</td>
<td>.81</td>
</tr>
<tr>
<td>night waking</td>
<td>.16</td>
<td>.06</td>
<td>.74</td>
</tr>
<tr>
<td>Percent of Variance</td>
<td>23.2</td>
<td>15.2</td>
<td>11.2</td>
</tr>
</tbody>
</table>
variables (i.e., nightmares, enuresis and snoring) had to be dropped due to low commonality (< 0.20) with other variables. Both the eigenvalues and scree plot indicated a three factor solution that accounted for 50 percent of the variance. Examination of the adequacy of the correlation matrix indicated that it was significantly different from an identity matrix (Bartlett Test of Sphericity = 346.84, p < .01) and had reasonable sampling adequacy (KMO = .71). Variables were retained for each factor if the critical value was greater than 0.38 (Norman and Streiner, 1994). Each factor had at least three variables. Only two variables (difficulty falling asleep and restless sleep) loaded on more than one factor, however, these loadings were less than the critical value for inclusion on the second factor (see Table 3). All primary factor loadings were considered at least adequate and fell above .50, with the majority falling in the .60 to .70 range (Tabachnick and Fidell, 1996). To ensure that the factors were internally consistent, reliability analysis were conducted for each of the three factors. Each factor had a standardized item alpha of .60 or greater, and no single item reduced the alpha level below that for the total scale.

The three factors reflect: 1) dyssomnias; 2) sleep-related involuntary movements; and 3) parasomnias, respectively. Various other approaches to Factor Analysis were conducted (e.g., factor axis analysis with varimax and oblique rotations), and each approach found the same factors with the same items loading on each factor. The validity of the factor structure was supported by the resemblance of these factors to current diagnostic classifications of childhood sleep problems (Ferber and Kryger, 1995). The reliability of these factors was supported by a similar factor structure found using the same questionnaire in an epidemiological sample of 972 children (Blader et al., unpublished...
Table 4: Base rates (%) of sleep problems by group

<table>
<thead>
<tr>
<th></th>
<th>Non-clinical Comparison Group (0)</th>
<th>Unmedicated ADHD Group (1)</th>
<th>Medicated ADHD Group (2)</th>
<th>Clinical Comparison Group (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FACTOR 1 (Dyssomnias)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>arising-weekdays</td>
<td>8.3</td>
<td>22.8</td>
<td>54.5</td>
<td>22.9</td>
</tr>
<tr>
<td>arising-weekends</td>
<td>2.8</td>
<td>5.1</td>
<td>4.5</td>
<td>5.7</td>
</tr>
<tr>
<td>bedtime resistance</td>
<td>0</td>
<td>35.4</td>
<td>36.4</td>
<td>34.3</td>
</tr>
<tr>
<td>onset problems</td>
<td>0</td>
<td>27.8</td>
<td>36.4</td>
<td>14.3</td>
</tr>
<tr>
<td>FACTOR 2 (Sleep-related involuntary movements)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sleep talking</td>
<td>0</td>
<td>7.6</td>
<td>13.6</td>
<td>5.7</td>
</tr>
<tr>
<td>teeth grinding</td>
<td>16.2</td>
<td>38.0</td>
<td>31.8</td>
<td>37.1</td>
</tr>
<tr>
<td>restless sleep</td>
<td>24.3</td>
<td>58.2</td>
<td>81.8</td>
<td>62.9</td>
</tr>
<tr>
<td>jerky movements</td>
<td>16.7</td>
<td>35.4</td>
<td>50.0</td>
<td>37.1</td>
</tr>
<tr>
<td>FACTOR 3 (Parasomnias)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sleep walking</td>
<td>2.8</td>
<td>11.4</td>
<td>27.3</td>
<td>17.1</td>
</tr>
<tr>
<td>night awakenings</td>
<td>0</td>
<td>8.9</td>
<td>9.1</td>
<td>5.7</td>
</tr>
<tr>
<td>night terrors</td>
<td>8.3</td>
<td>19.0</td>
<td>13.6</td>
<td>20.0</td>
</tr>
<tr>
<td>NOT INCLUDED</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>snoring</td>
<td>38.9</td>
<td>38.0</td>
<td>40.9</td>
<td>40.0</td>
</tr>
<tr>
<td>bedwetting</td>
<td>5.6</td>
<td>17.7</td>
<td>13.6</td>
<td>8.6</td>
</tr>
<tr>
<td>nightmares</td>
<td>0</td>
<td>2.5</td>
<td>4.5</td>
<td>5.7</td>
</tr>
<tr>
<td>% of subjects with 1 or more sleep problems</td>
<td>55.5</td>
<td>86.1</td>
<td>95.5</td>
<td>82.9</td>
</tr>
</tbody>
</table>

Notes: This table provides descriptive statistics for each individual sleep item. Individual analyses were not conducted, rather analyses were conducted based on factor scores.
The four groups were compared on each of the three factors. Group differences were found for Factor 1 (dyssomnias) and Factor 2 (sleep-related involuntary movements) (F(3, 168) = 6.47 and 3.69, p < .01; respectively), but not for Factor 3 (parasomnias). Post-hoc tests for both factors with group differences indicated all three clinical groups were reported to experience more sleep problems compared to the non-clinical comparison group. Table 4 includes base rates on each of the items within the factors as well as those items that had been dropped. The percentage of children in each group who evidenced at least one sleep problem ranged from 55 percent to 95 percent (X^2 = 18.89, p < .01).

Prediction of Current Sleep Problems

Examination of the bivariate correlations for Factor 1 (dyssomnias) indicated that dyssomnias were related to the combined subtype of ADHD (r = .17, p < .01), a diagnosis of ODD (r = .27, p < .01), and the use of stimulant medication (r = .17, p < .01). The results of the regression analysis are provided in Table 5. Step 1 (covariates) of the linear regression was not significant, indicating that age and sex were not related to the presentation of dyssomnias. In step 2, only the combined subtype of ADHD was found to be related to dyssomnias and accounted for 3 percent of the variance. Examination of the beta values for the other two subtypes (i.e., inattention subtype = .11, hyperactivity-impulsivity subtype = .06) indicated that they did not approach the same magnitude as the combined subtype. For step 3, two variables were found to be significant and were therefore entered into the regression model. A diagnosis of ODD accounted for an increase in the percentage of explained variance by 6 percent and the use of stimulant
Table 5: Regression results for Factor 1 (Dyssomnias) and Factor 2 (Involuntary Movements)

<table>
<thead>
<tr>
<th></th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>β</td>
<td>se</td>
<td>p</td>
</tr>
<tr>
<td><strong>Dyssomnias</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Covariates</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>age</td>
<td>.03</td>
<td>.05</td>
<td>.61</td>
</tr>
<tr>
<td>sex</td>
<td>.24</td>
<td>.20</td>
<td>.22</td>
</tr>
<tr>
<td>ADHD subtypes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Combined</td>
<td>.36</td>
<td>.17</td>
<td>.03</td>
</tr>
<tr>
<td>Potential Confounds</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ODD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>medication</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>IN VOLUNTARY MOVEMENTS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Covariates</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>age</td>
<td>.03</td>
<td>.05</td>
<td>.63</td>
</tr>
<tr>
<td>sex</td>
<td>.05</td>
<td>.20</td>
<td>.80</td>
</tr>
<tr>
<td>ADHD subtypes</td>
<td></td>
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<td>.39</td>
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<td>.02</td>
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<tr>
<td>Potential Confounds</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAD</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Notes:** β = beta value; se = standard error; p = p-value; ADHD = attention-deficit hyperactivity disorder; ODD = oppositional defiant disorder; SAD = separation anxiety disorder.
medication led to a 2 percent increase in the explained variance. The final model accounted for 12 percent of the variance and indicated that a diagnosis of ODD and use of stimulant medication were the only significant predictors of dyssomnias. The attenuation of the significance of the combined subtype was seen by the drop in the magnitude of the beta value. This indicates that the original significance of the combined subtype was confounded by its relationship with the other variables (i.e., ODD and medication). A direct comparison of the beta values for ODD and medication (both dummy variables) indicates that they make a similar contribution to the prediction of dyssomnias.

For Factor 2 (sleep-related involuntary movements), significant bivariate correlations were found between this factor and the combined subtype of ADHD ($r = .17$, $p < .01$), a diagnosis of GAD ($r = .16$, $p < .01$), and a diagnosis of SAD ($r = .27$, $p < .01$). The statistics for this regression can be found in Table 5. The step containing the covariates was not significant. For step 2, the combined subtype of ADHD was found to be a significant predictor of involuntary movements and accounted for 3 percent of the variance. The remaining two subtypes of ADHD did not approach significance (i.e., inattention subtype $= .06$, hyperactivity-impulsivity subtype $= .04$). For step 3, a diagnosis of SAD was found to be a significant predictor of involuntary movements, and accounted for an additional 7 percent of the variance. The final model accounted for 10 percent of the variance and both variables (combined subtype of ADHD and SAD) were found to be significant predictors of sleep-related involuntary movements. Although the inclusion of SAD did reduce the magnitude of the combined subtype of ADHD, it continues to make an independent contribution to the prediction of sleep-related involuntary movements. A
comparison of the beta values for these two variables indicates that SAD has twice the magnitude of influence on the outcome variable compared to the combined subtype (ADHD).

DISCUSSION

This is the first study that has attempted to disentangle the relationship between sleep problems, ADHD, comorbidity associated with ADHD, and treatment with stimulant medication. Results indicate that many latency-aged children have sleep difficulties, including normally developing healthy children. Although the children with ADHD were reported to evidence more problematic sleep characteristics than their normally developing peers, they did not differ from other children who were referred for a clinical assessment. In regard to specific sleep problem areas, parasomnias were found to be similar between clinical and non-clinical children, whereas dyssomnias were found to be related to confounding factors (i.e., comorbid disorders and stimulant medication) rather than ADHD. The only independent association between sleep problems and ADHD was that the combined subtype of ADHD was related to an increase in sleep-related involuntary movements. However, sleep-related involuntary movements were even more highly associated with anxiety. These results suggest that the relationship between ADHD and sleep problems depends on the type of sleep problem assessed, as well as confounding factors such as comorbidity and stimulant medication treatment.

In the present study there was a high rate of reported sleep problems found across all four groups. The percentage of children in each group who evidenced at least one sleep problem ranged from 55 percent to 95 percent (i.e., non-clinical comparison group: 55%
unmedicated ADHD group: 86%; medicated ADHD group: 96%; and clinical comparison group: 83%). These high rates of sleep problems are not likely to be the result of a sample bias, as comparisons on a global rating of sleep problems completed during the parent interview did not differentiate between study participants and study refusers. Moreover, parents in all clinical groups on average rated their children's sleep as "similar to their peers." and only two children in the sample had been treated for sleep problems (one child in the medicated ADHD group and one child in the clinical comparison group). Given that the rates of individual sleep problems found in this study are similar to previously reported prevalence statistics in community samples (e.g., Blader et al., 1997) and ADHD samples (e.g., Kaplan et al., 1987; Trommer et al., 1988), these high rates are more likely the result of screening for multiple sleep problems.

Consistent with previous research, the children with ADHD in comparison to their normally developing peers were reported to be experiencing more sleep problems in the area of dyssomnias and sleep-related involuntary movements. However, in the area of parasomnias the children with ADHD were reported to have similar difficulties as their normally developing peers. This finding represents the first systematic evaluation of parasomnias in children with ADHD. In addition to the sleep problems found in children with ADHD, they were also reported to have poorer sleep practices and a stronger history of sleep problems as youngsters and in their immediate family. This finding deserves further investigation as sleep practices and sleep histories of the child and family have not been systematically explored. Although the children with ADHD did not differ from the non-clinical group in their total sleep time on the weekends, the unmedicated ADHD group
were reported to sleep an additional 15 minutes on weekdays. While this finding was statistically significant and consistent with a few other studies (e.g., Ramos Platon et al., 1990; Tirosh et al., 1993), its clinical significance is questionable.

The ADHD groups did not differ from the clinical comparison group in their reported sleep routines, sleep practices, child and family history of sleep problems, or current sleep problems. In fact, the ADHD groups and clinical comparison group did not differ on any sleep measure used in the current study. This finding is supported by the results of the only other study that incorporated a clinical control group. Marcotte et al. (1998) found that the clinical groups (ADHD, LD, ADHD+LD) differed from a community-based control group, but did not differ from each other in their sleep-related problems (including sleep-related breathing problems) and their manifestation of sleepiness. This finding is particularly noteworthy as the vast majority of research has only compared ADHD groups to normal controls. The lack of appropriate comparison groups may have led to attributing sleep problems to ADHD that may be more accurately related to confounding factors.

Although the ADHD groups did not differ from the clinical comparison group on their reported sleep problems or factors associated with sleep problems, the combined subtype of ADHD was found to be associated with dyssomnias and sleep-related involuntary movements. However, the relationship between ADHD and dyssomnias was due to other contributing factors, and ultimately dyssomnias were found to be associated with stimulant medication use and a diagnosis of ODD. To date, no study has examined sleep in children with ODD, but clinically it would make sense that these children may
have difficulties complying with their caregivers requests around sleep routines. The finding that the use of stimulant medication increases the likelihood of experiencing dyssomnias is consistent with previous studies that found that stimulant medication prolongs sleep onset (see Corkum et al., 1998 for a review).

Consistent with findings from previous literature, the present study documented an association between ADHD (combined subtype) and sleep-related involuntary movements. However, when comorbidity was taken into account, anxiety (particularly separation anxiety) was found to be more highly associated with these sleep problems than ADHD, although both independently contributed. There are a number of possible interpretations of this finding. First, children with ADHD and a comorbid anxiety disorder may be vulnerable to stress which results in sleep-related involuntary movements. Second, this result may reflect a reporting bias in that parents of SAD children are more vigilant in monitoring their children's sleep and therefore are more aware of the sleep difficulties. Future research should focus on the relationship between ADHD, anxiety and sleep-related involuntary movements as well as the potential biases in parental reports of sleep problems.

Limitations

There are several limitations to the current study. Firstly, parental report rather than objective measures were employed. However, it is believed that this approach was a necessary preliminary step in order to begin to address many interrelated issues that could not be easily addressed with the use of time intensive and costly objective measures (i.e., polysomnographs). Secondly, the questionnaires did not include items that could address
sleep-related breathing problems. The one item (snoring) potentially related to sleep-related breathing problems was dropped from the factor analysis due to low commonality with other variables. However, the rates of this problem were similar across groups. In order for the field to advance, comprehensive, reliable and valid measures that address all areas of sleep problems need to be developed. Thirdly, the clinical comparison group was non-specific and evidenced some ADHD symptomatology. Future research needs to include various clinical comparison groups in order to further determine the specificity of sleep problems in childhood psychopathology.

Clinical Implications

The current study highlights the need for comprehensive assessment of sleep problems in latency-aged children, particularly in children who are seen in mental health settings. The importance of assessing and treating sleep problems in latency-aged children is underscored by the high percentage of sleep problems found in this study, as well as by previous documentation that indicates a negative impact of sleep problems on the functioning of the child and family (Saxby and Morgan, 1995). The assessment of sleep problems needs to cover a wide range of sleep difficulties, as well as consider information concerning the child's primary and comorbid diagnoses and medication use. It is important for the clinician to realize that many sleep problems may not be unique to ADHD. However, these sleep problems may exacerbate difficulties with behaviour and learning and therefore need to be addressed.
The following reliability and validity statistics are reported in Schachar et al., 1995.

Interrater agreement on the PICS for a diagnosis of ADHD, ODD or CD, and emotional disorder (ED) was 100 percent. On the TTI, agreement rates were 76 percent for ADHD and ODD, and 83 percent for CD. Convergent validity of the PICS and TTI with the Ontario Child Health Studies Scales were .65 for ADHD, .68 for ODD, .44 for CD, and .55 for ED.
CHAPTER 4

Actigraphy and parental ratings of sleep in children with attention-deficit/hyperactivity disorder.


Actigraphy and parental ratings of sleep in children with attention-deficit/hyperactivity disorder. Manuscript in preparation for submission.
ABSTRACT

Objective: To assess various sleep parameters in latency-aged children with ADHD and their normally developing peers through the use of multiple sleep measures.

Method: Six sleep parameters were evaluated for two groups of children, ADHD and normal comparison. Each group consisted of 25 children (20 males, 5 females) who ranged in age from 7 to 11 years. All children underwent rigorous diagnostic procedures and the ADHD subjects were selected only if they displayed pervasiveness in their symptomatology and were medication naive. Parents completed a retrospective questionnaire that evaluated sleep problems over the past six months. Additionally, each child was required to wear an actigraph for seven consecutive nights, and the child's parents completed a sleep diary during this time period.

Results: Based on the findings from the questionnaire, parents of children with ADHD reported significantly more sleep problems than parents of normally developing children. However, many of these differences in sleep were not verified through the actigraphy or sleep diary data, with the exception of longer sleep duration for children with ADHD and parent reports that describe increased bedtime resistance. It was also found that parent-child interactions during bedtime routines were more challenging in the ADHD group.

Conclusions: Despite the possibility of intrinsic sleep problems such as longer sleep duration, results indicate that many of the sleep problems of children with ADHD may be due to challenging behaviours during bedtime routines. The reason for discrepancies among sleep studies employing objective measures as well as between retrospective and prospective measures are discussed.
Numerous authors have commented on the parallels between the effects of sleep deprivation in children and the symptoms of attention-deficit/hyperactivity disorder (Brown et al., 1995; Dahl et al., 1991; Guilleminault et al., 1982; Picchietti and Walters, 1994; Sheldon et al., 1991; Weinberg, 1990). Children with ADHD and children suffering from sleep deprivation share a similar cognitive, behavioural and emotional profile (Dahl, 1996; Brown et al., 1995). Both groups have been found to experience difficulties on tests of executive functioning, exhibit problems with attention, impulsivity and restlessness, and have difficulties regulating their emotions (e.g., increased irritability). Paradoxically, sleep-deprived children can display these symptoms without demonstrating overt sleepiness. Although the effects of sleep deprivation in children is based primarily on anecdotal reports, these are supported by a small body of controlled studies (e.g., Randazza et al., 1997; Ishihara and Miyake, 1998), as well as by studies examining the effects of sleep deprivation in adults and animals (Pilcher and Huffcutt, 1995; Rechtschaffen et al., 1989).

Treatment studies also provide supporting evidence for a potential link between sleep disturbances and ADHD. For example, Dahl et al. (1991) reported on a case study of chronotherapy treatment for a latency-aged girl diagnosed with ADHD and a delayed sleep phase insomnia. This treatment resulted in improvements in ADHD symptomatology and learning that were both sustained over 18 months. Also, improvements in ADHD-like symptoms have been demonstrated in children who have been treated for sleep apnea (Ali et al., 1998; Guilleminault et al., 1982) and who have been treated for Periodic Limb Movement Disorder (Picchietti and Walter, 1994). Finally, the mainstay treatment for
ADHD, stimulant medication, is also indicated for the treatment of sleepiness in patients with narcolepsy (a primary sleep disorder).

The relationship between sleep disturbances and ADHD is further supported by numerous parental reports of sleep problems in children with ADHD. Based on subjective measures of sleep (e.g., questionnaires), parents of children with ADHD report that their children have more difficulty falling asleep, more night awakenings, shorter naps, more frequent motor movements during sleep, and increased tiredness upon waking when compared to parental reports from normal comparison groups (Kaplan et al., 1987; Trommer et al., 1988). However, objective measures (e.g., polysomnographs, actigraphy) yield little consistent evidence of differences in sleep between ADHD and normal samples. In our recent review of the literature, only three moderately consistent findings across studies were found. Compared to normal controls, children with ADHD had similar sleep durations, more movements during sleep, and stimulant medication negatively impacted sleep (Corkum et al., 1998). However, conclusions based on this literature are difficult as there are numerous methodological issues (e.g., small sample sizes, inconsistent diagnostic criteria and procedures, unclear medication status and inadequate control procedures).

Recently, the issue of specificity of sleep problems to children with ADHD has begun to be addressed (Corkum et al., in press; Marcotte et al., 1998). In a large-scale study (Corkum et al., in press) that conducted a factor analysis of a sleep questionnaire completed by parents, it was found that in comparison to normal controls, children with ADHD were reported to evidence more problems in the areas of dyssomnias (e.g., bedtime resistance, sleep onset difficulties, problems with morning awakening) and sleep-related
involuntary movements (e.g., restlessness, jerky movements, sleep talking, teeth grinding), but not parasomnias (e.g., night terrors, sleep walking, night waking). However, sleep problems found in the ADHD groups were also evident in a clinical comparison group. Since the clinical comparison group had sub-threshold levels of ADHD symptoms, regression analyses were conducted and it was found that dyssomnias were related to a diagnosis of oppositional defiant disorder and stimulant medication use rather than to an ADHD diagnosis. Involuntary movements were found to be more highly associated with a diagnosis of an anxiety disorder than a diagnosis of ADHD.

To date, there exists no theory that specifies the relationship between sleep and ADHD. However, it has been proposed that sleep deprivation in these children could be the result of a primary sleep disorder or related to dysregulation of arousal mechanisms, which has been implicated in the etiology of ADHD (Barkley, 1997). Both of these explanations indicate that sleep problems are intrinsic to children with ADHD (i.e., internally generated and specific to ADHD). Another possible explanation may be that sleep problems are extrinsic to ADHD (i.e., are not internally generated and not specific to ADHD). If sleep problems are intrinsic to ADHD, then it would be predicted that sleep problems reported by parents of children with ADHD could be verified through the use of objective measures. However, if sleep problems are extrinsic to ADHD, then reported sleep problems in this population would not be confirmed on objective measures of sleep.

The purpose of the current study was to test whether sleep problems in children with ADHD could be verified across multiple measures of sleep (i.e., questionnaire, sleep diary and actigraphy). The study examines six sleep parameters in a group of rigorously
diagnosed, medication naive, children with ADHD and a normal comparison group. The six parameters chosen are some of the most common parent reported sleep problems in children with ADHD (Day and Abmayr, 1998). These include difficulties with: 1) bedtime resistance; 2) sleep duration; 3) sleep onset latency; 4) night awakenings; 5) motor activity during sleep; and 6) arising in the morning. Whenever possible, these variables were examined separately for weekdays and weekends, as there are substantial differences between sleep and waking routines during these days. These differences have been shown to directly effect sleep duration (Szymczak et al., 1993). Also, Porrino et al., (1983) found that motor activity during sleep was significantly higher on weekdays than weekends.

METHOD

Subjects

The current sample consisted of 50 children, 25 children comprising the ADHD group and 25 children comprising the normal comparison group. There were 20 boys and 5 girls in each group, who ranged in age from 7.1 to 11.10 years. These children are a subsample from a study of parental report of sleep problems in ADHD, clinical and normal comparison groups (Corkum et al., in press). Exclusion criteria for participation in the original study included the following child variables: Verbal IQ and Performance IQ of less than 80, brain injury, pervasive developmental disorder, autism, psychosis, post-traumatic stress disorder, or a primary disorder of anxiety or affect.

Children diagnosed with ADHD from the original study were asked to participate in the current study if they were medication naive and reached diagnostic criteria for pervasiveness of ADHD symptoms (ie., children who demonstrated symptoms of ADHD in
both the home and school environment). All the children from the normal comparison group in the original study were given the opportunity to participate (this group is a non-referred community sample and were not receiving any treatment for attentional, behavioural, psychiatric, or learning difficulties). Of the eligible 115 subjects, 70 families chose to participate in the current study (41 ADHD, 29 normal comparison), which translates into participation rates of 51.9 percent for the ADHD group and 80.6 percent for the normal comparison group. For a child to be included in the study, it was required that at least four days of actigraphy and sleep diary data were successfully collected. Actigraphic equipment failure resulted in a loss of four children from the normal comparison group and twelve children from the ADHD group. No subject was lost due to sleep diary data because all parents completed at least four days. Four additional children were dropped from the ADHD group (i.e., the four youngest male children) in order to equate the groups on age and gender compositions. This resulted in complete data for the 25 ADHD subjects and 25 normal comparison subjects.

Each child underwent a rigorous diagnostic assessment, including parent and teacher diagnostic interviews and a comprehensive child psycho-educational assessment. In general, the diagnostic evaluation consisted of a face-to-face parent interview, a telephone interview with the child's teacher, and a comprehensive child assessment. The parent and teacher interviews were based on DSM IV (American Psychiatric Association, 1994) criteria for childhood externalizing and internalizing disorders and were administered by trained clinicians. These semi-structured interviews have been demonstrated to be reliable measures for use in diagnosing child psychopathology based on the DSM-III-R
(Schachar et al., 1995), and evaluation of reliability for *DSM-IV* is in progress. In addition to the diagnostic interviews, parents and teachers completed a number of questionnaires to provide supportive information. The child assessment consisted of various measures of cognitive processing, academic achievement and psychosocial functioning. The study was approved by the institutional ethics board and both parental consent and child assent were obtained.

**Subject Characteristics**

Table 1 presents subject characteristics as well as the percentage of children in each group who reached diagnostic criteria for the various subtypes of ADHD and for other externalizing and internalizing disorders. As per experimental design, the groups did not differ in their gender or age distributions. The mean age was 9.1 years for the ADHD group and 9.7 years for the normal comparison group. As typically found, the normal comparison and ADHD groups differed on IQ. More specifically, the mean IQ of the normal comparison group fell, the high end of the Average range, whereas the mean IQ of the ADHD group was in the middle of the Average range. Also, children in the ADHD group were more likely to have a comorbid learning disability (LD), which was defined by a standard score of at least 1.5 standard deviations below the age mean on either the reading or arithmetic subtests of the Wide Range Achievement Test-3 (Wilkinson, 1993). Given the most recent practice parameters for diagnosing a learning disability, an IQ-achievement discrepancy score was not employed (Fletcher et al., 1998).

Due to the fact that the *DSM-IV* does not specify an algorithm for pervasiveness or combining information across informants, this study employed a "6/4" algorithm to classify
Table 1: Subject and Diagnostic Characteristics

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>ADHD group (N = 25)</th>
<th>NC group (N = 25)</th>
<th>F-Value/$\chi^2$</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>age (years, months)</td>
<td>9.12 (1.42 sd)</td>
<td>9.72 (1.31 sd)</td>
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<td>.18</td>
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<tr>
<td>IQ</td>
<td>99.0 (16.10 sd)</td>
<td>114.08 (15.11 sd)</td>
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<td>LD</td>
<td>8 (32)</td>
<td>1 (4)</td>
<td>6.64</td>
<td>.01</td>
</tr>
</tbody>
</table>

Diagnoses

- Hyp-Imp: 5 (20) vs. 0 (0), F = 5.56, p = .02
- InA: 6 (24) vs. 0 (0), F = 6.82, p = .01
- Combined: 14 (56) vs. 0 (0), F = 19.44, p = .00
- ODD: 7 (28) vs. 2 (8), F = 3.39, p = .07
- CD: 8 (32) vs. 0 (0), F = 9.52, p = .00
- GAD: 4 (16) vs. 1 (4), F = 2.00, p = .16
- SAD: 3 (12) vs. 1 (4), F = 1.09, p = .30
- MD: 3 (12) vs. 0 (0), F = 9.52, p = .00

Notes: Unless otherwise specified the number to the outside of the bracket indicates the number of children with the diagnosis and the number inside the bracket represents the percent of the sample with the diagnosis. ADHD = attention-deficit/hyperactivity disorder; NC = normal comparison group; sd = standard deviation; IQ = intelligence quotient; LD = learning disabled; Hyp-Imp = hyperactivity-impulsivity subtype of ADHD; InA = inattentive subtype of ADHD; Combined = combined subtype of ADHD; ODD = oppositional defiant disorder; CD = conduct disorder; GAD = generalized anxiety disorder; SAD = separation anxiety disorder; MD = major depression.
ADHD subtypes. For this algorithm, both the parent and teacher interviews were given equal weight. To ensure pervasiveness across settings, the child had to exhibit a minimum of four symptoms in at least one cluster (i.e., inattention or hyperactivity-impulsivity) on both interviews. To meet diagnostic criteria for ADHD, the child also had to exhibit six symptoms of inattention or hyperactivity-impulsivity on either the parent or teacher interview, or on both interviews. For example, the combined subtype required evidence of at least six symptoms of inattention and six symptoms of hyperactivity-impulsivity, plus evidence of pervasiveness (i.e., at least four symptoms in one of the areas on the other interview). By design of the study, none of the children in the normal comparison group reached criteria for any subtype of ADHD. In the ADHD group, the combined subtype was the most common diagnosis (see Table 1).

A diagnosis of ODD and/or CD was given if the child reached diagnostic criteria for these disorders on either the parent and/or teacher interview. A diagnosis of generalized anxiety disorder (GAD), separation anxiety disorder (SAD), and/or major depressive episode (MD) was given if the child reached diagnostic criteria on the parent interview and/or was given a rating of "marked abnormality" on the screen included on the teacher interview. The ADHD group had more children with diagnoses for all externalizing and internalizing disorders, however, only differences in CD and MD reached statistical significance.

Measures

The Child Sleep Questionnaire - Parent Version

The Child Sleep Questionnaire - Parent Version (CSQ-P; Blader et al., 1997)
provides an assessment of sleep problems and sleep-related issues for elementary school-aged children. It was used previously in a community sample of 972 children between the ages of 5 to 12 years (Blader et al., 1997) and in a study of parental report of sleep problems in children with ADHD (Corkum et al., in press). The CSQ-P employs a predominantly multiple-choice format and assesses sleep routines, sleep practices, and current sleep problems over the past six months. The questionnaire is divided into four sections that focus on: 1) initial sleep; 2) middle sleep; 3) sleep termination; and 4) sleep-related issues (e.g., assessment/treatment for sleep problems).

A number of sleep indices have been previously developed (Corkum et al., in press), however, for the current study only information pertaining to six preselected sleep parameters was utilized. Five questions from the CSQ-P addressed specific sleep disturbances of interest (i.e., bedtime resistance, sleep onset difficulties, night waking, restlessness, and difficulties arising). Two of these items (sleep onset and night awakenings) were rated on a six point scale (0 "never" to 5 "every night"), one item (bedtime resistance) was rated on a five point scale (0 "never" to 4 "every night"), one item (difficulty arising) was rated on a four point scale (0 "no" to 3 "extreme") and one item (restlessness) was rated on a two point scale (i.e., yes/no). The sixth parameter, child's total sleep time, was calculated from questions about the child's typical bedtime and wake time. Of the above six sleep parameters, two items asked the parent to provide information separately for weekdays and weekends (i.e., sleep duration and difficulty arising).

Actigraphy

Actigraphs are used in sleep assessment to discriminate between sleep-wake states
through documentation of body movements. The actigraphs used in the current study were Basic Mini-Motionloggers from Ambulatory Monitoring, Inc. These actigraphs employ a piezoelectric beam sensor and have a fixed sensitivity at 2-3 Hz and detect accelerations greater than 0.01 g force. The mechanism is encased in a metal, water-proof case and has a 32K memory with a sampling rate of 10Hz. The actigraphs were initialized to employ zero-crossing mode using an auto actigraph interface with a built in comparator (i.e., a magnetically generated calibration signal for comparison of instrument performance over time and between units). The data was extracted using the ACT operational software and summary analyses were computed using the ACTIONW2 software that employed a validated sleep estimation algorithm (Sadeh et al., 1994). Prior to analyzing the data, they were visually inspected to reject any epochs where the actigraph had been removed. The actigraph has been found to have good face validity and its reliability has been documented in numerous studies (see Sadeh et al., 1995). Studies have found a high rate of agreement (85-90 percent) between actigraphy and polysomnography, and actigraphs have been found to distinguish between sleep disturbed and control children with success (for a review see Wiggs and Stores, 1995).

Four variables were computed using the actigraphic data (i.e., total sleep duration, sleep onset, number of night awakenings, and restlessness). Total sleep duration was defined as the number of minutes from sleep onset to wake onset. Sleep onset was measured in minutes from the time the parent indicated "lights out" by pressing the event marker to sleep onset which was defined automatically by the program as the first 20 minute block with greater than 19 minutes of sleep. The number of night awakenings was
defined as the number of blocks of contiguous wake epochs between the time of sleep onset and wake onset. Restlessness during sleep was defined as the mean frequency of motor movements per epoch from sleep onset to wake onset. All four sleep parameters were computed separately for weekday and weekend, using the occurrence of school attendance the next day as the definition of weekday (weekday: Sunday, Monday, Tuesday, Wednesday, Thursday; weekend - Friday, Saturday).

**Child Sleep Diary**

In the absence of any published sleep diaries for children, a comprehensive diary was developed specifically for this study. (A copy of the sleep diary can be obtained from the first author.) In general, sleep diaries are widely used in clinical settings and have been found to have reasonable face validity, high internal consistency and good agreement with videotapes of children's sleep (for a review see Wiggs and Stores, 1995). The diary collected information for a seven day period with identical questions for each day. Similar to the CSQ-P, the diary was divided into four sections - getting ready for bed, initial sleep, middle sleep and waking. Each section includes questions assessing various sleep parameters, as well as questions assessing the parent-child interactions related to these sleep parameters. Five specific sleep parameters were assessed: 1) bedtime resistance (difference between the time of the first call for bed and the time into bed); 2) sleep duration (difference between the time of sleep onset and the time of arising); 3) sleep onset (the difference between time of lights out and the time the child was reported to have fallen asleep); 4) night awakenings (the reported number of times the child awoke during the night); and 5) arising (difference between time of waking and the time of getting out of
bed). The definitions employed for identifying weekday and weekend sleep nights were the same as those used for actigraphy data.

In addition to the above measures, eight questions were completed by the parent that assessed the parent-child interactions during routines associated with sleeping and waking. These questions included: a) the number of calls required prior to the child beginning to get ready for bed; b) how the child reacted to the first call for bed; c) how the child responded to "lights out"; d) the number of times the child called/got out of bed prior to sleep onset; e) how the parent responded to the child calling/getting out of bed; f) how the parent responded to night awakenings; g) the number of calls in the morning to awaken child; and h) if the child awoke spontaneously in the morning. All eight questions were answered either with a numerical value (e.g., the number of calls) or were rated on a three point scale for each night, based on parents' responses on the sleep diary. For parental response the scale was: 0 = "limited or no response needed (e.g., call back to child)"; 1 = "moderate response needed (e.g., go to child's room to check on him/her)"; 2 = "a lot of response needed (e.g., stay in child's room, bring child to parent's bed)". For child response the scale was: 0 = "positive, no problems (e.g., no complaining, bargaining, etc.)"; 1 = "OK, a few problems"; 2 = "poorly, a lot of problems (e.g., lots of complaining, bargaining, etc.)".

Procedure

The parent most familiar with the child's bedtime and waking routines completed the CSQ-P during the initial diagnostic assessment. After completing the questionnaire, a research assistant scanned the questionnaire for missing data and the parent was asked to
complete any missing information (this usually occurred over the telephone). If the family had provided consent to participate in the study, orientation to the actigraph and sleep diary occurred approximately one week after the diagnostic assessment.

The family and child were provided with general information on how the actigraph worked and then it was placed on the wrist of the child's non-dominant hand. Instructions were given to remove the actigraph only for showers/baths and when the child was to be engaged in contact sports or swimming. The format and use of the sleep diary was explained to the parent(s) of each child. Specifically, parents were instructed that the diary was to be completed by the parent responsible for bedtime and morning time routines. It was to be completed as soon as possible after the child went to sleep and when the child got up in the morning. The actigraph was to be worn and the sleep diary completed for one full week. After the one week period, the actigraph and sleep diary were collected from the family's home.

Analysis

The Statistical Package for Social Sciences (SPSS) was used for all analyses. The results of the study are presented in three sections: 1) sleep questionnaire; 2) actigraphy; and 3) sleep diary. All of the analyses of the sleep parameters based on data from the sleep diary and actigraphy used repeated measures ANCOVA with age as a covariate, group as the between subject factor, and day of the week (weekday versus weekend) as the within subject factor. The majority of analyses based on the CSQ-P were not evaluated separately for weekday and weekend (i.e., bedtime resistance, sleep onset, night waking, restlessness), rather these variables were analyzed using an ANCOVA with age as a covariate. For
restlessness, a Chi Square analysis was used to analyze the parents' responses. For items addressing parent-child interactions, information was analyzed by Chi-square and one-way analysis of variance.

RESULTS

The Child Sleep Questionnaire - Parent Version

Compliance rates for completing the CSQ-P were 100 percent. Table 2 displays bed and wake times as well as the means, standard deviations, ranges, F-values and p-values for each of the sleep parameters on the CSQ-P. A significant difference between the groups was found on five of the six sleep parameters. The ADHD group was reported to have more bedtime resistance, longer sleep durations (weekdays: 27 minutes; weekends: 19 minutes), and more difficulty with sleep onset. Also, more of the ADHD subjects were considered "restless sleepers" and they were reported to have more difficulties with waking in the morning. The two groups did not differ in the frequency of night awakenings. For the variable of difficulties arising there was a group by day interaction that indicated that the ADHD group had more difficulties arising on the weekdays compared to the normal comparison group.

Actigraphy

Of the 50 subjects included in the study, 36 subjects (80%) had actigraphic data for seven days, ten subjects had six days, three subjects had five days and one subject had four days. Of the 14 subjects (seven children from each group) who did not have seven days of actigraphic data, but who were still included in the study because they had completed the minimal requirement of at least four days, three stopped wearing the actigraphy early and
### Table 2: Data from The Child Sleep Questionnaire - Parent Version

<table>
<thead>
<tr>
<th>Sleep Problem</th>
<th>Measurement</th>
<th>ADHD</th>
<th>NC</th>
<th>Group</th>
<th>Days</th>
<th>G X D</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(n = 25)</td>
<td>(n = 25)</td>
<td>F/X²</td>
<td>p</td>
<td></td>
</tr>
<tr>
<td>Bed Time</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>8:39 (41)</td>
<td>8:53 (33)</td>
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<td>[8:00 - 10:00]</td>
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<tr>
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<td>9:27 (50)</td>
<td>9:42 (41)</td>
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<td>N/A</td>
<td>N/A</td>
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<td>[8:30 - 11:00]</td>
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<td></td>
</tr>
<tr>
<td>Wake Time</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>weekdays</td>
<td>time-AM (sd-min)</td>
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<td>7:02 (25)</td>
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<td>N/A</td>
<td>N/A</td>
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<td>N/A</td>
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<td>[6:00 - 11:00]</td>
<td>[6:30 - 10:30]</td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>Bedtime Resistance</td>
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<td>1.04 (0.68)</td>
<td>34.8</td>
<td>.000</td>
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<tr>
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<td>[1-4]</td>
<td>[0-2]</td>
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<td></td>
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<td>Sleep Duration</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>weekdays</td>
<td>minutes (sd)</td>
<td>638 (25)</td>
<td>611 (41)</td>
<td>4.16</td>
<td>0.05</td>
<td>0.47</td>
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<td>[510 - 660]</td>
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<td></td>
<td>0.50</td>
</tr>
<tr>
<td></td>
<td>weekends</td>
<td>629 (56)</td>
<td>610 (44)</td>
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<td>0.60</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[range]</td>
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<td>[540 - 690]</td>
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<td></td>
</tr>
<tr>
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<td>1.56 (1.58)</td>
<td>0.60 (0.82)</td>
<td>6.03</td>
<td>0.02</td>
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</tr>
<tr>
<td>----------------</td>
<td>-----------------------------</td>
<td>-------------</td>
<td>-------------</td>
<td>------</td>
<td>------</td>
<td>-----</td>
</tr>
<tr>
<td>Night Waking</td>
<td>mean (sd) scale 0-5 [range]</td>
<td>0.56 (1.12)</td>
<td>0.24 (0.60)</td>
<td>1.00</td>
<td>.32</td>
<td>N/A</td>
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<tr>
<td>Motor Activity</td>
<td># subjects (%) yes response</td>
<td>15 (60.0%)</td>
<td>5 (20.0%)</td>
<td>8.33</td>
<td>.004</td>
<td>N/A</td>
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<tr>
<td>Arising weekdays</td>
<td>mean (sd) scale 0-3 [range]</td>
<td>1.08 (0.91)</td>
<td>0.40 (0.65)</td>
<td>9.43</td>
<td>.004</td>
<td>23.9</td>
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<tr>
<td>Arising weekends</td>
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<td>0.32 (0.56)</td>
<td>0.16 (0.48)</td>
<td>6.46</td>
<td>.01</td>
<td></td>
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</tbody>
</table>

Notes: For all analyses the df = (1,49); All analysis are ANCOVA except for motor activity which is a Chi-square; ADHD = attention-deficit/hyperactivity disorder; NC = normal comparison group; Group = main effect of group; Days = main effect for days of the week (weekdays versus weekend); G X D = group by days interaction; F = F-value; $X^2$ = Chi-square; p = p-value; sd = standard deviation; min = minute; range = minimum and maximum data point.
the data was lost from the remaining 11 children because of actigraphic equipment failure. Two of the six sleep parameters were not available based on actigraphic data (i.e., bedtime resistance and difficulties arising).

Table 3 documents bed and wake times as well as the means, standard deviations, ranges, F-values, and p-values for the four sleep variables assessed by actigraphy. There were no group differences on any of the four sleep parameters. However, a trend was noted in sleep duration, with the ADHD group sleeping an additional 17 minutes on the weekdays and 30 minutes on the weekends. A number of additional indices of motor activity (e.g., mode of activity, standard deviation of activity, percent quiet sleep) were examined, however, none were significant or even approached significance. Confirmatory analyses were conducted whereby only children with complete seven day data were included (18 children in each group). These analyses resulted in similar findings as the initial analyses, with the exception of a new significant finding - a main effect for days of the week (i.e., both the ADHD and normal comparison groups evidenced more motor movements during sleep on weekends, compared to weekdays).

**Sleep Diary**

The majority of subjects completed the sleep diary for the entire seven days (N = 44, 88 percent of the sample), with three subjects completing six days and three subjects completing four days. Of the six subjects who did not complete the sleep diary for seven days, three had discontinued both the actigraphy and the sleep diaries early, and the other three continued with the actigraphy, but did not complete the sleep diaries. All of the sleep parameters were available on the sleep diary, with the exception of a measure of
Table 3: Actigraphy Data

<table>
<thead>
<tr>
<th>Sleep Problem</th>
<th>Measurement</th>
<th>ADHD (n = 25)</th>
<th>NC (n = 25)</th>
<th>Group F</th>
<th>Days F</th>
<th>G X D F</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>p</td>
<td>p</td>
<td>p</td>
</tr>
<tr>
<td>Sleep Time</td>
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<td></td>
<td></td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>weekday</td>
<td>time-PM (sd-min)</td>
<td>9:48 (51)</td>
<td>10:08 (40)</td>
<td>[8:05 - 11:15]</td>
<td>[8:47 - 11:42]</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>[range]</td>
<td>[8:05 - 11:15]</td>
<td>[8:47 - 11:42]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>10:22 (66)</td>
<td>10:51 (54)</td>
<td>[7:58 - 11:50]</td>
<td>[9:40 - 1:38AM]</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>[7:58 - 11:50]</td>
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<td></td>
<td></td>
<td></td>
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<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>weekends</td>
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<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Wake Time</td>
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<td>7:13 (45)</td>
<td>[6:15 - 8:40]</td>
<td>[5:46 - 8:48]</td>
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<tr>
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<td>[range]</td>
<td>[6:15 - 8:40]</td>
<td>[5:46 - 8:48]</td>
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<tr>
<td></td>
<td></td>
<td>7:45 (54)</td>
<td>7:43 (46)</td>
<td>[6:08 - 9:12]</td>
<td>[6:31 - 9:46]</td>
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</tr>
<tr>
<td></td>
<td>[range]</td>
<td>[6:08 - 9:12]</td>
<td>[6:31 - 9:46]</td>
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</tr>
<tr>
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<td></td>
<td></td>
<td></td>
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<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Bedtime Resistance</td>
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<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Duration</td>
<td>minutes (sd)</td>
<td>570 (33)</td>
<td>553 (41)</td>
<td>3.23</td>
<td>.08</td>
<td>1.06 .31</td>
</tr>
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<td>[475 - 626]</td>
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<tr>
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<td>568 (53)</td>
<td>538 (54)</td>
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</tr>
<tr>
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<td>[416 - 668]</td>
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<td>Onset</td>
<td>weekdays</td>
<td>minutes (sd)</td>
<td>weeks (sd)</td>
<td>range</td>
<td>range</td>
<td></td>
</tr>
<tr>
<td>------------------</td>
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<tr>
<td></td>
<td></td>
<td>22.4 (8.9)</td>
<td>25.2 (11.9)</td>
<td>[6 - 44.4]</td>
<td>[6 - 60]</td>
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<td>weekends</td>
<td>17.9 (9.8)</td>
<td>26.5 (24.5)</td>
<td>[5 - 41.5]</td>
<td>[4.5 - 99]</td>
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<tr>
<td>Wakings</td>
<td>weekdays</td>
<td># of contiguous wake epochs (sd)</td>
<td>15.1 (7.3)</td>
<td>16.6 (6.6)</td>
<td>2.01</td>
<td>.16</td>
</tr>
<tr>
<td></td>
<td>weekends</td>
<td>15.0 (5.1)</td>
<td>16.5 (5.7)</td>
<td>[7.5 - 24.5]</td>
<td>[5.5 - 27.0]</td>
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<tr>
<td>Motor Activity</td>
<td>weekdays</td>
<td># movements (sd)</td>
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<td>13.0 (4.9)</td>
<td>0.40</td>
<td>.44</td>
</tr>
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<td>weekends</td>
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<td>[5.4 - 30.7]</td>
<td>[7.33 - 19.9]</td>
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<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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</tbody>
</table>

**Notes:** For all analysis the df = (1,48); All analysis are ANCOVA; ADHD = attention-deficit/hyperactivity disorder; NC = normal comparison group; Group = main effect of group; Days = main effect for days of the week (weekdays versus weekend); G X D = group by days interaction; sd = standard deviation; min = minute; range = minimum and maximum data point.
### Table 4: Sleep Diary Data

<table>
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<th>Sleep Problem</th>
<th>Measurement</th>
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<th>NC (n = 21)</th>
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<th>Days</th>
<th>G X D</th>
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<td>[8:10 - 11:22]</td>
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<td></td>
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<tr>
<td>weekdays</td>
<td>[range]</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>weekends</td>
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<td>9:59 (53)</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Wake Time</td>
<td>time-AM (sd-min)</td>
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<td>7:02 (30)</td>
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<td>N/A</td>
<td>N/A</td>
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<td>[range]</td>
<td>[6:33 - 7:55]</td>
<td>[6:08 - 7:42]</td>
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<td></td>
</tr>
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<td>weekends</td>
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<td>7:33 (44)</td>
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<td></td>
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<td>Bedtime Resistance</td>
<td>minutes (sd - min)</td>
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<td>18.9 (10.6)</td>
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<td>.006</td>
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<td>[7 - 46]</td>
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<tr>
<td>Duration</td>
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<td>567 (44)</td>
<td>4.91</td>
<td>.03</td>
<td>.34</td>
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<td>[477 - 637]</td>
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<td>551 (51)</td>
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<td>[473 - 660]</td>
<td>[480 - 675]</td>
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<tr>
<td></td>
<td>Onset minutes (±d)</td>
<td>Wakings # wake episodes (±d)</td>
<td>Motor Activity</td>
<td>Arising minutes (±d)</td>
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<td>range</td>
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<td>range</td>
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</tr>
<tr>
<td>weekdays</td>
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<td>5.4 (3.8)</td>
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<tr>
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<td>5.8 (7.6)</td>
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<td>[0 - 70]</td>
<td>[0 - 1.2]</td>
<td></td>
<td>[0 - 33]</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>15.4 (7.6)</td>
<td>0.19 (0.29)</td>
<td></td>
<td>7.6 (8.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>[0 - 31]</td>
<td>[0 - 1.2]</td>
<td></td>
<td>[0 - 31]</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.09 .30</td>
<td>0.39 .53</td>
<td></td>
<td>1.69 .20</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.17 .69</td>
<td>0.01 .91</td>
<td></td>
<td>0.63 .43</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.36 .55</td>
<td>0.08 .78</td>
<td></td>
<td>0.49 .45</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: For all analysis df = (1,47); All analysis are ANCOVA; ADHD = attention-deficit/hyperactivity disorder; NC = normal comparison group; Group = main effect of group; Days = main effect for days of the week (weekdays versus weekend); G X D = group by days interaction; sd = standard deviation; min = minute; range = minimum and maximum data point.
restlessness (see Table 4). For the sleep parameters of onset, night waking and morning arising, there were no main effects for group or days of the week, or interactions. There was a significant group effect for bedtime resistance, with the children with ADHD having a longer time between the first call to get ready for bed and the time of actually going to bed. There also was a significant group effect for sleep duration, with the ADHD group sleeping an additional 12 minutes on the weekdays and 18 minutes on the weekends.

The parent-child interactions associated with bedtimes were found to be more problematic for the ADHD group (see Table 5). The ADHD group required twice as many calls for bed and three times the number of children with ADHD responded poorly to these calls on at least one night over the week. Also, parents of children with ADHD were required to use at least moderate interventions on one or more nights in order for their children to go back to bed prior to sleep onset. There were no differences between the groups in the children's response to "lights out" or the level of interventions required for night awakenings. Also, the groups did not differ in the number of morning calls required to awaken the child. Moreover, the children in both groups did not differ on the number of mornings that they awoke spontaneously over the course of the week.

DISCUSSION

The current study indicates that in addition to the possibility that children with ADHD may have intrinsic sleep problems, there is a need to consider an alternative explanation - that some of the most commonly reported sleep problems may be extrinsic in nature. The majority of sleep parameters that were reported by the parents of children with ADHD to be problematic were not verified through the use of sleep diaries and actigraphy.
Table 5: Qualitative questions on the sleep diary

<table>
<thead>
<tr>
<th>Question</th>
<th>Data Presentation</th>
<th>Statistical Test</th>
<th>ADHD (n = 25)</th>
<th>NC (n = 25)</th>
<th>F-value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;How many calls did it take before your child began to get ready for bed?&quot;</td>
<td>mean # of calls per night (sd)</td>
<td>F</td>
<td>2.13 (1.01)</td>
<td>1.29 (0.37)</td>
<td>14.98</td>
<td>.0003</td>
</tr>
<tr>
<td>&quot;How did your child react to the first call for bed?&quot;</td>
<td># of children who reacted poorly on at least one night (%)</td>
<td>( \chi^2 )</td>
<td>10 (40)</td>
<td>3 (12)</td>
<td>5.09</td>
<td>.02</td>
</tr>
<tr>
<td>&quot;How did he/she respond to &quot;lights out&quot;?</td>
<td># of children who responded poorly on at least one night (%)</td>
<td>( \chi^2 )</td>
<td>3 (12)</td>
<td>1 (4)</td>
<td>1.09</td>
<td>.30</td>
</tr>
<tr>
<td>&quot;How many times did your child call out or get out of bed after lights out and before falling asleep?&quot;</td>
<td>mean # of incidents per night per child (sd)</td>
<td>F</td>
<td>.91 (1.50)</td>
<td>.47 (0.61)</td>
<td>1.88</td>
<td>.18</td>
</tr>
<tr>
<td>&quot;How did the parent respond?&quot;</td>
<td># of children who required at least moderate interventions on a minimum of one night (%)</td>
<td>( \chi^2 )</td>
<td>17 (68)</td>
<td>5 (20)</td>
<td>11.69</td>
<td>.0006</td>
</tr>
<tr>
<td>&quot;How did the parent respond to night wakings?&quot;</td>
<td># of children who required at least moderate interventions on a minimum of one night (%)</td>
<td>( \chi^2 )</td>
<td>3 (12)</td>
<td>2 (8)</td>
<td>0.22</td>
<td>.64</td>
</tr>
<tr>
<td>&quot;How many calls to awaken him/her?&quot;</td>
<td>mean # of calls per morning (sd)</td>
<td>F</td>
<td>0.82 (0.83)</td>
<td>0.64 (0.59)</td>
<td>0.87</td>
<td>.35</td>
</tr>
<tr>
<td>&quot;How did he/she awake in the morning?&quot;</td>
<td># of days awoke on own</td>
<td>F</td>
<td>3.72 (2.32)</td>
<td>4.12 (2.20)</td>
<td>0.39</td>
<td>.53</td>
</tr>
</tbody>
</table>

Notes: For all analysis df = (1, 49); ADHD = attention-deficit/hyperactivity disorder; NC = normal comparison group; # = number; sd = standard deviation; % = percent.
Based on these measures, the groups differed only in that the ADHD group had increased bedtime resistance and longer sleep durations. Supporting evidence for the role of challenging behaviours in sleep problems was found on a number of items that reflect difficulties in parent-child interactions during bedtime routines. Taken together these findings raise the possibility that some of the reported sleep problems may be related to challenging behaviours that often exist in children with ADHD.

Based on the questionnaire data, the ADHD group was reported to have more bedtime resistance, difficulty with sleep onset, restlessness during sleep, difficulties arising in the morning, as well as a longer sleep duration. The finding that sleep in children with ADHD and their normally developing peers differs based on retrospective questionnaires is consistent with previous research (Kaplan et al., 1987; Trommer et al., 1988). The only sleep parameter examined on the questionnaire that did not differentiate between the ADHD and normal comparison groups was the frequency of night awakenings. This is not surprising, as night awakenings have been found to be problematic in preschool aged samples with ADHD, but not latency-aged samples (Kaplan et al., 1987; Trommer et al., 1988).

Similar to the finding on the questionnaire, the frequency of night awakenings did not differentiate between the ADHD and normal comparison groups based on actigraphy or sleep diary data. Moreover, there were also no differences on the sleep diary or actigraphy for the sleep parameters measuring sleep onset latency, difficulties arising, or motor movements, despite the fact that these were reported sleep problems. Previous research has been inconsistent in regard to differences in sleep onset latency, with shorter, longer and
similar sleep onset being found (see Corkum et al., 1998). No other study has examined
difficulties arising using actigraphy and/or sleep diaries. The finding of similar motor
movements during sleep in both the ADHD and normal comparison group is somewhat
inconsistent with previous literature, with the majority of studies employing actigraphy
finding that children with ADHD move more frequently during sleep (e.g., Dagan et al.,
1997; Glod et al., 1997; Porrino et al., 1983).

The reason for this discrepancy between previous research and our findings of
similar motor movements during sleep may be related to measurement issues. For
example, previous studies collected data for varying time periods (e.g., two to seven days).
did not control for day of the week, used a variety of brands of actigraphs with different
placements (e.g., wrist, waist), and analyzed the data using different sleep-wake
algorithms. Another potential confound that has rarely been controlled for in previous research, is the
past or current use of stimulant medication and the comorbidity of the subject sample. For
example, stimulant medication and anxiety both have been found to be linked to increased
motor movements. Although the findings in the current study are not consistent with the
majority of past research, they are very similar to those of Tirosh et al., (1993) who used a
analogous methodology in a sample with similar subject characteristics (e.g., medication
naive). The current findings are also comparable to a number of studies employing
polysomnography (Greenhill et al., 1983; Nahas and Krynicki, 1977).

The two consistent findings across measures were that children with ADHD
evidenced more bedtime resistance and slept for a longer duration than children in the
normal comparison group. Longer sleep durations appeared to be related to an earlier sleep
time, as both groups reported similar waking times. On average, the questionnaire data indicated a 23 minute difference, the sleep diary data indicated a 17 minute difference, and the actigraphy data indicated a 20 minute difference. This finding is in contrast to the majority of findings from previous studies. For example, in our review of the literature (Corkum et al., 1998) there was no difference in sleep duration in nine out of ten studies reviewed. The reason for this discrepancy may also be related to methodological issues. Many of the previous studies had small sample sizes and therefore may have not had the power to detect these differences. Also, many of these studies did not control for past or present use of stimulant medication. Controlling for the use of stimulants is important as Tirosh et al. (1988) found that stimulant medication reduced sleep duration in children with ADHD.

Although there was a significant main effect for group on sleep duration, there was no day of the week effect or day of the week by group interaction. This finding would indicate that the difference in sleep duration was similar for both weekdays and weekends. To extrapolate from this finding, there was no evidence that the ADHD sample were "catching up" on sleep during the weekend that could potentially have indicated that these children were sleep deprived. However, this finding needs to be interpreted with caution, as examination of waking times on weekends indicated that many of the children were continuing to awake at a similar time as on weekdays. It is not possible with the current data to determine if the weekend wake times were free from scheduled waking times (i.e., some children may have early morning sports activities that compelled them to rise early, etc.). Another finding that does not support the notion of sleep deprivation is that both
groups awoke spontaneously during the week on a similar number of days. It would be expected if the ADHD group were sleep deprived then they would awaken spontaneously less often than normal controls. An alternative explanation is that increased sleep duration may be related to increased need for sleep as a result of high daytime activity level exhibited in unmedicated children with ADHD. Future research examining this issue is important to replicate our findings and determine why children with ADHD require more sleep.

The finding that the ADHD group evidenced more bedtime resistance is a consistent finding in past research. The current study extended past findings by exploring the nature of challenging behaviours across both bedtime and wake time. The current study found that in the ADHD group, parents needed to call their children more frequently to get them ready for bed, received poorer response from their children for these bedtime calls, and their children require more adult attention to settle for the night. Interestingly, the challenging behaviours were not found during waking routines. The reason why challenging behaviours would only be evident at night time needs to be further investigated.

Overall, the findings of the current study confirm our previous findings (Corkum et al., in press) which indicated that sleep problems defined as dyssomnias (i.e., bedtime resistance, and difficulties with sleep onset and arising in the morning) are related to a diagnosis of oppositional defiant disorder, rather than to a diagnosis of ADHD. Oppositional defiant disorder has been found to be comorbid with a diagnosis of ADHD in up to 90 percent of these children. Also, the lack of verification of sleep problems through
objective measures is consistent with our previous review of the literature (Corkum et al., 1998). The exact extent that challenging behaviours affects parents' ratings of sleep problems needs to be further investigated. For example, when asked to rate how problematic sleep onset is for their children, parents may have difficulty separating sleep onset problems from bedtime resistance.

The current study sought to address many of the methodological weaknesses of previous research. First, it used both subjective and objective measures that were separate and distinct from diagnostic and daytime behaviour measures. Second, the study applied these sleep measures to a large sample of children who were all medication naive. Third, all subjects underwent rigorous diagnostic procedures and were diagnosed as having pervasive ADHD (ie., ADHD symptoms in both the home and school environment). Fourth, the ADHD and comparison groups were equated on age and gender composition which is important given the developmental changes in sleep. Finally, the study also employed rigorous experimental procedures. For example, the goal of the current study was to collect sleep diary and actigraphy data for a total of seven days, which has been recommended in recent research (Acebo et al., 1999).

There are a number of limitations of the current research. First, there may have been a sampling bias, with participation being driven by sleep-related issues. However, it was found that participants from the original ADHD group were similar in their diagnostic profile to non-participants, with the exception of a higher frequency of parent-reported current and past sleep problems. This should have biased the study in the direction of finding more differences between groups. Secondly, the current study only assessed a
circumscribed number of potential sleep problems and therefore is limited in the
generalizability of the findings. Third, the measures employed in the study are not
sensitive to all the dimensions of sleep (see Teicher et al., 1996 for a discussion of the
limitations of actigraphy). For example, actigraphy does not measure EEG features of
sleep. Moreover, the most commonly used actigraphs measure frequency of motor
movements, but not other dimensions such as amplitude.

Future research should continue to explore reasons for discrepancies between parent
reports of sleep problems and the lack of verification of these sleep problems on objective
measures. Several explanations have been suggested to account for these discrepancies
(Abmayr and Day, 1994; Ball and colleagues 1995, 1997; Greenhill et al., 1983; Kaplan et
al., 1987). These explanations include that: 1) parents of children with ADHD may
complete questionnaires with a negative response bias, leading them to over-report all
behavioural problems; and 2) parents of children with ADHD may have a lower threshold
for reporting difficulties. The current study suggests that rather than a perceptual bias, two
additional hypothesis should be considered: 1) that "over-reporting" of sleep problems may
be influenced by difficult behaviours associated with sleep routines; and 2) that the
differences are not between subjective and objective measures, but between retrospective
and prospective measures. The first hypothesis was supported by the fact that parents of
children with ADHD consistently reported more challenging behaviours during sleep
routines. Also, parents in the ADHD group provided closer estimates of sleep parameters
on the sleep diary when compared to the actigraphy data, which indicates that they were not
"over-reporting". Rather, these parents may be truly experiencing these as "sleep
problems”, albeit not necessarily intrinsic in nature. The second hypothesis is supported by the fact that findings were similar between sleep diary (a subjective measure) and actigraphy (an objective measure). However, differences in findings existed between retrospective accounts (that reflected problems over the last six months) and prospective accounts (that reflected sleep problems over the last seven days).

The findings from the current study underscore the importance of using behavioural interventions for sleep problems in medication naive children with ADHD as the first line of treatment. Behavioural interventions should consist of strategies to help reduce parent-child struggles that occur during bedtime routines. Also, parents might be well advised to allow for a longer sleep time for their child with ADHD.
CHAPTER 5

Conclusions
It is commonly believed that children with ADHD evidence sleep difficulties. however, there is no theory that explicitly states the link between ADHD and sleep problems. It has been proposed that children with ADHD could suffer from a primary sleep disorder or that their sleep problems may be related to dysregulation of arousal. In either case, children with ADHD would be expected to be experiencing sleep deprivation that could cause or exacerbate ADHD symptomatology. An alternative explanation regarding the association of sleep problems in children with ADHD is that the sleep problems most commonly associated with ADHD are extrinsic in that they are a manifestation of challenging behaviour. If sleep problems are intrinsic to a diagnosis of ADHD then it was predicted that: 1) certain sleep problems would be specific to a diagnosis of ADHD; 2) reported sleep problems would be verified on an objective measure; and 3) there would be evidence of sleep deprivation. If sleep problems are extrinsic to a diagnosis of ADHD then it was predicted that the ADHD group would not evidence: 1) specificity of sleep problems; 2) verification of sleep problems on an objective measure of sleep; and 3) signs of sleep deprivation.

The present thesis includes three studies that all address the nature of the association between ADHD and sleep problems. The first study (Chapter 2) was a systematic review of the literature, which employed a box-score analysis of studies since 1970 that examined sleep in children with ADHD. Based on this review, two main discrepancies in the literature became evident. First, there was a discrepancy between the results found in studies that employed subjective measures (e.g., retrospective questionnaires) compared to studies that used objective measures (e.g., polysomnographs, actigraphy). In general, it
was found that in studies employing subjective measures, parents of children with ADHD report many more sleep problems (mostly problems with the timing, duration and continuity of sleep) than parents of normal controls. However, studies employing objective measures found little consistent evidence for sleep problems in children with ADHD.

The second discrepancy highlighted in the review of the literature was the inconsistency of findings across studies that employed objective measures of sleep. The only consistent findings based on the 16 studies reviewed were: that children with ADHD had greater restlessness during sleep; stimulant medication negatively impacted sleep; and sleep duration was similar between children with ADHD and their normally developing peers. Three key methodological issues were felt to account for many of the inconsistency of findings across studies. Firstly, the majority of previous studies employed poor diagnostic procedures and did not take into account psychiatric comorbidity. This is particularly important as approximately 50 to 80 percent of children with ADHD present with comorbid diagnoses, such as oppositional defiant disorder, conduct disorder, anxiety, depression, and learning disabilities. Many of these comorbid diagnoses are known to be related to sleep problems (e.g., Coble et al., 1984; Teicher et al., 1996). Secondly, the use of stimulant medication was not well controlled in previous research. This is important as stimulant medication is known to affect sleep in children and adults (Segalowitz et al., 1994). Thirdly, the existing studies employed small sample sizes, often including less than ten ADHD subjects.

Two empirical studies were conducted as part of this thesis (Chapters 3 and 4). Both studies carefully attended to the methodological issues described above (i.e., all
children included in the empirical studies were rigorously diagnosed, medication status was controlled for, and sample sizes were large in comparison to previous studies). The study reported in Chapter 3 represents one of the first studies in the literature to begin to address the issue of specificity of sleep problems to ADHD by testing four hypotheses. The hypotheses tested whether sleep problems are: 1) similar in children with ADHD as compared to the normal population; 2) associated with ADHD through their relationship with other comorbid diagnoses; 3) associated with stimulant medication use; and/or 4) directly associated with a diagnosis of ADHD. The results did not provide unilateral support for the proposition that particular sleep problems are specific to ADHD.

Parasomnias (e.g., sleep walking, night terrors) were found to be reported at similar rates in the ADHD and normal comparison groups. Parents of children with ADHD reported more sleep problems in the area of dyssomnias (e.g., difficulty with sleep onset, arising in the morning). However, this finding was not specific to the ADHD group, as parents in the clinical comparison group also reported significant sleep problems in this area. Detailed analyses indicated that dyssomnias were related to oppositional defiant disorder and stimulant medication use, rather than a diagnosis of ADHD. Involuntary movements (e.g., restlessness, jerky legs.) were also found to be more frequently reported in the ADHD group compared to the normal comparison group. However, there were no differences in reported rates between the ADHD and clinical comparison groups. Detailed analysis indicated that sleep-related involuntary movements were associated with a diagnosis of the combined subtype of ADHD, but this particular sleep problem was even more highly associated with a diagnosis of an anxiety disorder.
The study reported in Chapter 4 examined whether sleep problems could be verified across multiple sleep measures (i.e., questionnaire, diary, actigraphy) and represents the first study that employed multiple measures of sleep in a group of latency-aged children with ADHD. It was found that on retrospective questionnaires, parents of children with ADHD reported more sleep problems than did parents of normally developing peers. However, many of these reported sleep problems were not verified through the use of projective and objective sleep measures (i.e., sleep diaries and actigraphy), with the exception of a longer sleep duration and increased bedtime resistance in the ADHD group. A number of variables that differentiated the ADHD and normal comparison groups were related to difficulties in parent-child interactions during bedtime routines. The results of this study were interpreted as indicating that some of the "sleep problems" reported by parents could be related to challenging behaviours during bedtime routines.

The results from the three studies taken together provide preliminary support for the notion that some of the most commonly reported sleep problems in children with ADHD may be extrinsic in nature. For example, there was minimal evidence for specificity of sleep problems in the ADHD group, and the majority of the reported sleep problems were not verified on sleep diary or actigraphy data. However, there was one finding across the two empirical studies that suggests that children with ADHD may have an intrinsic sleep problem. Parental report of longer sleep duration was found to be specific to unmedicated children with ADHD (Chapter 3), and was verified on both sleep diary and actigraphy data (Chapter 4). The exact interpretation of this finding is at this time speculative. First, this finding needs to be replicated in future studies, as the majority of past research has found
that children with ADHD have similar sleep durations. If this finding is upheld in future research, it may be that children with ADHD require more sleep due to their increased activity during the day, or that these children have a deficiency of wakefulness (i.e., central nervous system underarousal that leads to difficulty maintaining a vigilant state).

As previously noted, the strength of the studies contained in this thesis lies in the attention given to methodological issues. For example, the subjects were rigorously diagnosed and comorbid disorders were identified and attended to experimentally. Also, careful attention was given to control procedures, such as the issue of past and current use of stimulant medication. The specific limitations to each study are discussed in the related chapters. Globally, the results of this thesis are limited by the choice of sleep measures used in each of the empirical studies. For example, rather than using polysomnographs ("the gold standard sleep measure"), specificity of sleep problems was based on parental reports, and reported sleep problems were tested through the use of sleep diaries and actigraphy. Although each of these sleep measures has limitations, it was believed that this was an appropriate step prior to using polysomnography which is costly and labour intensive, as well as presenting with its own limitations (e.g., the validity of measures taken from a child in an unfamiliar sleep laboratory over a couple of nights).

The results of the current research have direct implications for clinical practice. It would appear prudent to assess children with ADHD for sleep disturbances, as these have been reported as a significant stressor for parents, and treatment of sleep problems has resulted in improvements in daytime functioning. The assessment of sleep needs to cover a wide range of sleep problem areas, as well as consider information concerning the child's
primary and comorbid diagnoses and medication use. It is important for the clinician to realize that issues around sleep may not be unique to ADHD, however, these sleep problems may exacerbate difficulties with behaviour and learning, and therefore need to be addressed. The first line of treatment should consist of behavioural interventions targeting challenging behaviours around bedtime routines. Finally, parents might be well advised to allow for a longer sleep duration for their child with ADHD.


Bergman RL (1976), Treatment of childhood insomnia diagnosed as "hyperactivity". *J Behav Ther & Exp Psychiatry* 7: 199


Brown TE, Gammon GD (1992), ADHD-associated difficulties falling asleep and awakening: clonidine and methylphenidate treatments. Presented at the *Scientific Meetings of the American Academy of Child and Adolescent Psychiatry*, Washington, DC


Norman GR, Streiner DL (1994), *Biostatistics: The bare essentials*. Mosby, St Louis, MO


Rechtschaffen A, Bergmann BM, Everson CA et al. (1989), Sleep deprivation in the rat: X. Integration and discussion of findings. *Sleep* 12: 68-87


APPENDIX A

The Child Sleep Questionnaire - Parent Version

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cxi
SLEEP QUESTIONNAIRE
Part A: General Information

Child's Name: ___________________________ Date of Birth: _________________
Parent's Name: ___________________________ Today's Date: _________________

The following questions inquire about your child's sleep habits and the circumstances that may have an effect on his/her sleep. Please answer all questions by circling the appropriate number on multiple choice questions or by writing in your own answer where applicable.

WE WOULD PREFER THAT THIS BE FILLED OUT BY THE ADULT WHO IS MOST FAMILIAR WITH THE CHILD'S SLEEP HABITS.

1. What is your relationship with the child: ___________________________

2. What is the age of the child for whom you are filling out this questionnaire:
   (years) (months)

3. Child's Sex: Male Female

4. Does your child have a regular bedtime? Yes No
   If yes, what time?
   ______ Week Days ______ Weekends
   If no, what time does he/she usually go to bed?
   ______ Week Days ______ Weekends

5. Does your child generally share his/her bedroom with another person?
   0. Sleeps alone in room
   1. Sleeps in room with younger sibling
   2. Sleeps in room with older sibling
   3. Sleeps in room with parent(s)
   4. Sleeps in room with other adult (not parent)
   5. Sleeps in room with other child (not sibling)
6. Does your child generally share his/her bed with another person?
   0. Sleeps alone in bed
   1. Sleeps with younger sibling
   2. Sleeps with older sibling
   3. Sleeps with parent(s)
   4. Sleeps with other adult (not parent)
   5. Sleeps with other child (not sibling)

7. Does your child sleep with a house pet in his/her room?  Yes  No

8. How would you describe the room where your child sleeps? (Circle all that apply)
   1. dark
   2. bright
   3. noisy
   4. quiet
   5. close to parent's room
   6. close to sibling's room
   7. close to common areas (e.g., living room, kitchen)

9. At what age did your child stop taking naps on a daily basis?
   1. Less than one year of age
   2. One to two years of age
   3. Two to three years of age
   4. Three to four years of age
   5. Four to twelve years of age
   6. My child still takes naps

If your child is still taking naps, how frequently does he/she take them?  If yes, how long do the naps last?
   1. Less than once a week
   2. One to two times a week
   3. Three to four times a week
   4. Five to six times a week
   5. Everyday
   1. A half an hour
   2. A half an hour to one hour
   3. One to two hours
   4. Three or more hours
10. How old was your child when he/she started to sleep through the night on a regular basis?
   1. One to six months of age
   2. Six to twelve months of age
   3. One to two years of age
   4. Two to three years of age
   5. More than three years of age
   6. Child does not sleep through the night

11. Has your child ever gone to a sleep-a-way camp? Yes No
   If yes, did the camp report any sleep difficulties while your child was there? Yes No

12. Has your child ever slept away from home, without parents or siblings
   (not including sleep-a-way camp)? Yes No
   If yes, did the caretaker report any sleep difficulties while your child was there? Yes No

**Initial Sleep**

Please keep in mind your child's sleep over the past six months.

13. Does your child require a light on to fall asleep? Yes No

14. Does your child require his/her bedroom door to be open when going to sleep? Yes No

15. It is sometimes difficult to get a child to go to bed. How often is it difficult to get your child to go to bed?
   0. Never difficult
   1. Less than once a week
   2. One to two times per week
   3. Three to four times a week
   4. Every night
If there is any difficulty, what is the main reason that your child does not go to bed when he/she is supposed to?
1. Noncompliance: refuses to go to sleep when told
2. Disorganization: has not completed bed time preparations (e.g., brushing teeth, etc.)
3. Fearfulness
4. Outside noise
5. Other: ________________________________
   (please specify)

16. In general, does your child initially fall asleep in his/her own bed?
0. Yes, in own bed
1. No, in parents' bed
2. No, in living room
3. No, in sibling's room
4. Other: ________________________________
   (please specify)

If no, how often does he/she fall asleep in another location (not his/her own bed)?
1. Less than once a week
2. One to two times a week
3. Three to four times a week
4. Five to six times a week
5. Every night

**Adult Interventions**

17. Are there any special interventions (actions) that you (or another person) routinely do with your child before he/she falls asleep? (Circle all that apply)
0. No interventions
1. A bedtime story
2. Rubbing back, or caressing
3. Warm milk
4. Other: ________________________________
   (please specify)

If yes, are any of these interventions necessary for your child to fall asleep?  Yes  No
Child Activity

18. Which of the following bedtime rituals does your child engage in before he/she falls asleep? (Circle all that apply)
   0. No rituals
   1. Takes a stuffed animal to sleep with
   2. Uses a security blanket
   3. Checks room (to make sure room is safe)
   4. Other: ____________________________
      (please specify)

If yes, are any of these a necessity for your child to get in bed? Yes No

19. Does your child express any fears or worries before he/she goes to bed? (Circle all that apply)
   0. No fears or worries
   1. Harm/death of self
   2. Harm/death of parents
   3. Monsters
   4. Robbers
   5. Darkness
   6. Other: ____________________________
      (please specify)

20. Does your child have any difficulty falling asleep at night?
   0. No difficulty
   1. Less than once a week
   2. One to two times a week
   3. Three to four times a week
   4. Five to six times a week
   5. Every night
If yes, how long does it take for your child to fall asleep?
1. Less than half an hour
2. A half an hour to an hour
3. One to two hours
4. Two to three hours
5. More than three hours
6. Do not know

If yes, for how long has your child had difficulty falling asleep? ________ ________
age of child: (years) (months)

21. How do you regard your child’s behaviour regarding getting to sleep compared to other children his/her own age?
1. The same as average
2. More problematic than average
3. Less problematic than average
4. Unable to make a comparison

22. Do you give your child any medication to help him/her fall asleep? Yes No

If yes, what type of medication is it?

1. Prescription: _______________________________________________________
   (name of medication)

2. Over the counter drug: ______________________________________________
   (name of medication)
Middle Sleep

Please keep in mind your child's sleep behaviour over the past six months.

23. Does your child have difficulty sleeping through the night?
   0. No difficulty
   1. Less than once a week
   2. One to two times a week
   3. Three to four times a week
   4. Five to six times a week
   5. Every night

If yes, how often does he/she wake up during the night?
   1. Awakens only one time
   2. Awakens two or three times
   3. Awakens three or four times
   4. Awakens five or more times
   5. Do not know

If yes, how long does it usually take for your child to fall back to sleep?
   1. Less than 15 minutes
   2. 15 to 30 minutes
   3. 30 minutes to one hour
   4. One to two hours
   5. Two or more hours
   6. Do not know

If yes, what is the main reason that your child does not sleep through the night?
   1. Nightmares (bad dreams)
   2. Enuresis (bed wetting)
   3. Outside noise
   4. Woken up by sibling or another person
   5. Hunger or thirst
   6. Other: __________________________________________________

   (please specify)
If yes, what attempts do you (or a person older than your child), make to help your child get back to sleep? (Circle all that apply)

1. No intervention by parent(s) or another person
2. Take child into your bed to fall asleep
3. Sleep with child in his/her own bed
4. Talk or sing to child
5. Give child a drink
6. Reprimand or scold him/her
7. Take child back to his/her room
8. Other: ________________________________
   (please specify)

24. Does your child ever complain about nightmares (bad dreams)?

   0. Never complains about nightmares
   1. Less than once a week
   2. One to two times a week
   3. Three to four times a week
   4. Five to six times a week
   5. Every night

25. Has your child ever experienced night terrors and what was the frequency?

   (Night terrors are not bad dreams; your child wakes you up with a loud scream or cry but remains asleep himself, he is sweaty, his heart is pounding, he appears anxious or agitated, and has no recollection of the incident on awakening).

   0. No night terrors
   1. Less than once a week
   2. One to two times a week
   3. Three to four times a week
   4. Five to six times a week
   5. Every night

   If yes, at what age did your child have his/her last night terror? _______ _______  
   (years) (months)
26. Is enuresis (bed wetting) a problem for your child?
   0. No bed wetting
   1. Less than once a week
   2. One to two times a week
   3. Three to four times a week
   4. Five to six times a week
   5. Every night
   If yes, does it wake him/her up during the night? Yes No

27. Does your child ever talk in his/her sleep?
   0. Never talks in his/her sleep
   1. One to four times in the past six months
   2. One to two times a week
   3. Three to four times a week
   4. Five to six times a week
   5. Every night
   6. Do not know

28. Does your child sleepwalk?
   0. Never walks in his/her sleep
   1. One to four times in the past six months
   2. One to two times a week
   3. Three to four times a week
   4. Five to six times a week
   5. Every night

29. Does your child snore in his/her sleep? Yes No

30. Does your child grind his/her teeth during sleep? Yes No

31. Does your child make jerky movements with his/her arms and legs during sleep? Yes No

32. Is your child a restless sleeper? (Is the bed dishevelled when he/she wakes up?) Yes No
33. How do you regard your child's behaviour after falling asleep compared to other children of his/her own age?
   1. The same as average
   2. More problematic than average
   3. Less problematic than average
   4. Unable to make a comparison

**Waking Up**

Please keep in mind your child's sleep behaviour over the past six months.

34. Does your child have any difficulty getting out of bed in the morning?
   On **weekdays** (Mon. - Fri.)?
   0. No difficulty
   1. A little difficulty
   2. Moderate difficulty
   3. Extreme difficulty

   On **weekends** (Sat. & Sun.)?
   0. No difficulty
   1. A little difficulty
   2. Moderate difficulty
   3. Extreme difficulty

35. In your opinion, does your child get enough sleep (is he/she tired during the day)? Yes  No

36. Does your child complain about being tired?   Yes   No

37. What usually wakes your child in the morning? (Circle what is most typical on school days)
   1. An alarm clock
   2. A parent
   3. Does so by him/herself
   4. A sibling
   5. Other: __________________________________________________________________ (please specify)
38. What time does your child wake up?
   _______ weekdays
   _______ weekends

39. Does your child wake up earlier than you would like?
   On weekdays  Yes  No
   On weekends  Yes  No

40. What does your child most often do when he/she wakes up?
   On weekdays (Mon. - Fri.)?
   1. Wakes up parent(s)
   2. Gets dressed and eats breakfast
   3. Plays, procrastinates
   4. Stays in bed, awake
   5. Watches television
   6. Other: ________________________________
      (please specify)
   On weekends (Sat. & Sun.)?
   1. Wakes up parent(s)
   2. Gets dressed and eats breakfast
   3. Plays, procrastinates
   4. Stays in bed, awake
   5. Watches television
   6. Other: ________________________________
      (please specify)

41. How do you regard your child's behaviour regarding waking up compared to other children his/her own age?
   1. The same as average
   2. More problematic than average
   3. Less problematic than average
   4. Unable to make a comparison
Related Issues

42. Does your child drink caffeinated sodas?
   0. Does not drink caffeinated sodas
   1. Less than one can a day
   2. One can a day
   3. One to two cans a day
   4. Three to four cans a day
   5. More than four cans a day

43. Does your child drink coffee or tea (or iced tea)?
   0. Does not drink coffee or tea
   1. Less than one cup a day
   2. One cup a day
   3. One to two cups a day
   4. Three to four cups a day
   5. More than four cups a day

44. Does your child eat chocolate?
   0. Does not eat chocolate
   1. Eats less than one bar (or equivalent) per week
   2. Eats one bar (or equivalent) per week
   3. Eats two to three bars (or equivalent) per week
   4. Eats more than three bars (or equivalent) per week

45. Has your child had his/her tonsils removed? Yes No
    If yes, at what age were they removed? _______(years) _______(months)

46. Has your child had his/her adenoids removed? Yes No
    If yes, at what age were they removed? _______(years) _______(months)

47. Has your child ever seen someone for sleep problems?
    If yes, who did they see? ___________________________________________
    and what were the recommendations? ________________________________
The Child and Family Sleep History Questionnaire

Part A: Developmental History

*This questionnaire looks at your child's sleep since he/she was an infant. Please place an "X" in the boxes of the sleep problems your child experienced during these years. Only place an "X" if you feel that your child's problem was more serious than other children of the same age.*

### INFANCY (Birth to 1 year)

- [ ] night waking
- [ ] trouble settling/falling asleep
- [ ] problems waking in morning
- [ ] trouble napping
- [ ] colic (excessive irritability)
- [ ] stopping breathing during sleep
- [ ] loud breathing during sleep
- [ ] headbanging/bodyrocking
- [ ] bedtime crying
- [ ] short total sleep time
- [ ] daytime sleepiness
- [ ] restless sleep
- [ ] none of the above

### PRESCHOOLER (1 to 4 years)

- [ ] night waking
- [ ] trouble settling/falling asleep
- [ ] problems waking in morning
- [ ] trouble napping
- [ ] daytime sleepiness
- [ ] unrefreshing sleep
- [ ] snoring
- [ ] stopping breathing during sleep
- [ ] bed-wetting
- [ ] headbanging/bodyrocking
- [ ] sleep walking
- [ ] sleep talking
- [ ] teeth grinding
- [ ] night terrors
- [ ] none of the above

### SCHOOL-AGED (5 to 12 years)

- [ ] night waking
- [ ] trouble settling/falling asleep
- [ ] problems waking in morning
- [ ] daytime sleepiness
- [ ] short total sleep time
- [ ] unrefreshing sleep
- [ ] snoring
- [ ] stopping breathing during sleep
- [ ] bed-wetting
- [ ] headbanging/bodyrocking
- [ ] night terrors
- [ ] nightmares
- [ ] restless sleep
- [ ] sleep walking
- [ ] sleep talking
- [ ] teeth grinding
- [ ] none of the above
Part B: Family History

This questionnaire looks at your child's family history of sleep problems. Record the name and age of each of the following family members (in relation to the child for which you are completing this form). For example, if he/she has one sister and one brother place their names on the lines labelled Sibling #1 and Sibling #2. Also record their age and gender (ie., male or female). Then circle "Yes" if they are a biological relative and "No" if they are not a biological relative.

| NAME       | AGE | GENDER | BIOLOGICAL?
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Mother</td>
<td></td>
<td></td>
<td>Yes / No</td>
</tr>
<tr>
<td>Father</td>
<td></td>
<td></td>
<td>Yes / No</td>
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<tr>
<td>Sibling #1</td>
<td></td>
<td></td>
<td>Yes / No</td>
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<td>Sibling #2</td>
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<td>Sibling #3</td>
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<tr>
<td>Sibling #4</td>
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<td>Yes / No</td>
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</table>

Directions: Circle the family member(s) who have experienced the following sleep problems. Record only if they were felt to be a significant problem.

RELATION TO CHILD

Trouble falling asleep
Trouble staying asleep
Body movements/jerks during sleep
Restless sleeper
Short sleeper (less than 5 hours)
Falling asleep during day (unplanned)
Sleep walking
Sleep talking
Grinding teeth in sleep
Nightmares
Night terrors
Bed-wetting
Growing pains
Part B: Family History continued

Has anyone in your immediate family (e.g. your child's parents and siblings) ever sought medical treatment for sleep problems? No Yes

Please list the type of sleep problem and/or any treatment received for each of the following relations:

<table>
<thead>
<tr>
<th>RELATIONSHIP</th>
<th>TYPE OF SLEEP PROBLEM</th>
<th>TREATMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mother</td>
<td></td>
<td></td>
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<tr>
<td>Father</td>
<td></td>
<td></td>
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<tr>
<td>Sibling #1</td>
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<tr>
<td>Sibling #2</td>
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<tr>
<td>Sibling #3</td>
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<td></td>
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<tr>
<td>Sibling #4</td>
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</tr>
</tbody>
</table>

Has anyone in your extended family (e.g., grandparents, uncles, aunts, etc.) ever sought medical treatment for sleep problems? No Yes

Please list the type of sleep problem and/or any treatment they received:

<table>
<thead>
<tr>
<th>RELATIONSHIP TO CHILD</th>
<th>TYPE OF SLEEP PROBLEM</th>
<th>TREATMENT</th>
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</thead>
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APPENDIX C

The Child Sleep Diary

© Penny Corkum, 1996
SLEEP DIARY

PSYCHIATRY RESEARCH
HOSPITAL FOR SICK CHILDREN

Penny Corkum, M.A., Ph.D. Candidate
813-7462

Child's Name: ____________________________________________

Start Date: ________________  End Date: ________________

GENERAL INSTRUCTIONS

• Please leave dairy in a convenient location

• It is important to fill out this diary on a few occasions every day (evening and morning)

• Do not rely on your memory, rather fill out the diary as things happen

• Remember to press the event button on the "watch" at "lights out" and first wake up call

• If you have any questions please call Penny Corkum at 813-7462
DAY 1

Date: ________________

Did your child have the "watch" off today? (please indicate times and reason)

________________________________________
________________________________________
________________________________________

Getting Ready for Bed

First call to start to get ready for bed: ____ PM

What was he/she doing at this time:
____ watching TV
____ reading
____ computer/computer games
____ playing outside
____ other (please list: ____________________________)

How did he/she react to the call for bed?
____ positively, no problems (e.g., no complaining, bargaining, etc.)
____ OK, a few problems
____ poorly, a lot of problems (e.g., lots of complaining, bargaining, etc.)

How many calls did it take before he/she began to get ready for bed: ____
What time did he/she begin to get ready for bed: ____ PM

Which activities did he/she have to do before going to bed:
____ getting pyjamas on
____ bath/shower
____ washing/brushing teeth
____ use the toilet
____ prepare for next day (choose clothing, pack school books)
____ other (please list: ____________________________)

What time did he/she get into bed? ____ PM

What did he/she do after getting into bed and prior to "lights out":
____ have a book read by parent
____ read a book on own
____ listen to music
____ back rub, kiss/hug
____ parent needs to lie down with child
____ other (please list: ____________________________)

What time was "lights out"? ____ PM (Remember to press button on "watch" at this time)

How did he/she respond to "lights out":
____ positively, no problems (e.g., no complaining, bargaining, etc.)
____ OK, a few problems
____ poorly, a lot of problems (e.g., lots of complaining, bargaining, etc.)
**Initial Sleep**

How many times did he/she call parent (but not get out of bed) prior to falling asleep? ____

How many times did parent need to respond? ____

How did parent respond?
___ limited or no response needed (e.g., call back to child, etc.)
___ moderate response needed (e.g., go to child’s room to check on him/her, etc.)
___ a lot of response needed (e.g., stay in child’s room, bring child to your room, etc.)

How many times did he/she get up after "lights out" prior to falling asleep? ____

How many times did parent need to respond? ____

How did parent respond?
___ limited or no response needed (e.g., call back to child, etc.)
___ moderate response needed (e.g., go to child’s room to check on him/her, etc.)
___ a lot of response needed (e.g., stay in child’s room, bring child to your room, etc.)

What reasons were given for getting out of bed:
___ had to use the washroom
___ hungry/thirsty
___ not tired
___ other (________________________)

Approximately, what time did he/she fall asleep: ____ PM

**Middle Sleep**

Once asleep did he/she awake during the night: Yes  No

How many times: ____

How many times did parent need to respond? ____

How did parent respond?
___ limited or no response needed (e.g., call back to child, etc.)
___ moderate response needed (e.g., go to child’s room to check on him/her, etc.)
___ a lot of response needed (e.g., stay in child’s room, bring child to your room, etc.)

What were the reasons for these night awakening(s):
___ bad dream/screaming out at night
___ had to use the washroom
___ hungry/thirsty
___ bed-wetting
___ sleep walking
___ awaken by someone else/noise
___ other
**Waking Up**

What time did he/she awaken this morning: ____ AM

(*Remember to press button upon child awakening*)

How did he/she awake this morning (check all that apply):

___ Alarm
___ Parent
___ Combination of alarm and parent
___ On own
___ Other (____________________________________)

What time did he/she get out of bed this morning: ____ AM

If parent had to awaken him/her, how many calls did it take: ____

What time did your child have to leave the house this morning? ____ AM

Was it rushed to finish all the morning routines? Yes No

What was your child's mood upon awakening? (rate on the following five point scale)

<table>
<thead>
<tr>
<th>mood</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>good-natured</td>
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<tr>
<td>alert</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>irritable</td>
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<td></td>
<td></td>
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<tr>
<td>lethargic</td>
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</table>

**General Information**

How would you rate your child's sleep last night compared to most nights:

<table>
<thead>
<tr>
<th>sleep</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>typical</td>
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<tr>
<td>atypical</td>
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</tbody>
</table>

How would you rate your child's waking up this morning compared to most mornings:

<table>
<thead>
<tr>
<th>wake</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>typical</td>
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<td></td>
</tr>
<tr>
<td>atypical</td>
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</table>

Please record any events which may have affected your child's sleep or waking up:
APPENDIX D

Actigraphy

Ambulatory Monitoring, Inc.
731 Saw Mill River Road
P.O. Box 609
Ardsley, New York 10502
Tel: 1-800-341-0066
Fax: 1-914-693-6604
Web site: www.ambulatory-monitoring.com
The actigraphs used in the study were Basic Mini-Motionlogger from Ambulatory Monitoring, Inc. These actigraphs employ a piezoelectric beam sensor and have a fixed sensitivity at 2-3 Hz. The mechanism is encased in a metal, water-proof case and has a 32K memory with a sampling rate of 10Hz. The actigraph has a side mounted event button with an audible feedback signal to ensure that data collection is ongoing. The actigraphs were initialized to employ zero-crossing mode using an auto actigraph interface with a built in comparator (i.e., a magnetically generated calibration signal for comparison of instrument performance over time and between units). The data was extracted using the ACT operational software and summary analysis were computed using the ACTIONW2 software which provides analysis for activity and sleep using a validated sleep estimation algorithm (Sadeh et al., 1989). A brief description of the available options and the program used in the current study follows.

Epoch Time: Epoch time refers to the unit of time in which the actigraph collects data in a temporary area before storage. Options range from one seconds to ten minutes, depending on the level of detail required, with more details requiring shorter epoch lengths. The current study used one minute epochs.

Packing Option: The packing option refers to the number of bits set aside for each data value in the 32K memory. The recommended packing option "C" was employed in the current study which allocated 10 bits of memory and allowed for a 16 day run time (with the even button being employed).
**Event Mode:** The event mode allows subjects to press an external button on the side of the actigraph in order to specify an event. Each child's parent(s) was instructed to press the event marker at "lights out" and when the child arose in the morning.

**Wake-up and Stop Time:** The actigraphs were initialized to start immediately and to end only when the data was downloaded into the computer. All extraneous data was trimmed prior to the analyses being conducted.

**Mode of Operation:** The Zero Crossing Mode was employed in the current study. This mode is essentially a activity frequency count and is the primary mode of operation in sleep estimation.

**Amplifier Setting:** This parameter was set at "18" as required in order to employ sleep estimation algorithms in corresponding software (i.e., ACTIONW2).

**Battery:** Duracell coin cell batteries DL2430B were used in this study, as recommended by Ambulatory Monitoring, Inc. A ten day battery life is estimated given the above parameters.

**Care and Maintenance:** Each actigraph was cleaned with alcohol swabs and the battery was replaced prior to re-initializing for each new subject. The wrist band was switched when required. In addition to general maintenance, comparative analysis were ran every six months to ensure that the individual units were well calibrated. A staff member from Ambulatory Monitoring, Inc. had one site visit in which all equipment was checked for accuracy of functioning.