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COMORBIDITY OF PEDIATRIC MIGRAINE AND SLEEP DISTURBANCES: THE ROLE OF A DYSFUNCTIONAL AUTONOMIC NERVOUS SYSTEM

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ABSTRACT OF DISSERTATION

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A dissertation completed in partial fulfillment of the
requirements for the degree of Doctor of Philosophy in the
College of Arts and Sciences
at the University of Kentucky

By
Debra B. Huss, M.A.

Lexington, Kentucky

Director: Dr. Richard Milich, Professor of Psychology

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THE ROLE OF A DYSFUNCTIONAL AUTONOMIC NERVOUS SYSTEM

This study compared psychological and physiological differences between children diagnosed with migraine and their healthy peers. Physiological measures were obtained at baseline, after discussing an emotionally relevant stressor, and after recovery in 21 children with pediatric migraine and 32 healthy peers. Comparisons were also made on psychological measures investigating sleep problems, anxiety, and family stress. It was hypothesized that children with migraine compared to their peers 1) would report more sleep disturbances, anxiety, and family stress 2) would exhibit greater sympathetic activation at rest, in response to an emotional stressor, and after a recovery period and 3) that autonomic functioning would mediate the relation between the presence of pediatric migraine and sleep disturbances. Results indicated that the migraine group reported significantly greater anxiety compared to peers but there were no significant differences in sleep disturbances or family stress. Within the migraine group, migraine severity was significantly associated with total sleep disturbance and greater incidence of parasomnias, while migraine duration was significantly associated with greater night time awakenings. Migraine children also exhibited a significantly higher pulse rate compared to their peers at rest and a significantly higher diastolic blood pressure and marginally significant higher LF/HF ratio at recovery from an emotional stressor. These findings suggest that sleep disturbance and pediatric migraine are significantly related but the relation is unclear and warrants additional research. Results also indicate that children with migraine may experience more anxiety than peers. Of most interest, results suggest that children with migraine may experience a disinhibition of the autonomic nervous system characterized by a dominance of the sympathetic nervous system resulting in a longer recovery period following an emotional stressor.

KEYWORDS: Pediatric Migraine, Heart Rate Variability, Stress,
Autonomic Nervous, System Functioning, Headache

Debra B. Huss
November 19, 2007

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For most of my life, my academic pursuits have been the major focus of my mental, physical, and emotional energy. I knew from an early age the career path I wanted for myself. Although my goals were clear and focused, the road to obtaining my doctoral degree in clinical psychology was longer and bumpier than originally expected. There were unexpected detours and obstacles. A wise man once told me that reaching the goal was never as sweet as the pursuit of the goal. In my academic pursuits, this is definitely the case. There were times of struggle, challenge, and misery coupled with times of laughter, successes, and meaningful relationships. All of these experiences helped me mature into a sensitive, intelligent clinician who values relationships.

There are many people who traveled this road with me for whose support gave me light and direction in times where the path was dark and unwelcoming. Without them, I would not be here celebrating this achievement today. First and foremost, I have to give special thanks to my mentor and generous advisor Richard Milich, PhD. He agreed to advise me despite having a full load of responsibilities himself and without knowledge of my research interests. His support and belief in my abilities resulted in me being awarded research and clinical recognition that was unexpected. I credit his mentorship with my successful completion of graduate school and internship as well as my growth as a clinician, a researcher, and as an individual.

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Chapter One

Introduction

Background

Migraine and sleep problems are both commonly reported in children, and both can adversely impact a child's life (Holmes, MacGregor, & Dodick, 2001). Studies indicate that the prevalence of pediatric migraine among the general population in both the United States and abroad is around 10% and increases with age (Lee & Olness, 1997; Abu-Arefeh & Russell, 1994; Sillanpaa, 1994; Mortimer, Kay, & Jaron, 1992; Sillanpaa, 1976). Furthermore, migraines appear to be a persistent problem even into adulthood. Bille (1997) found that over half of the children who experienced migraines when they were young (7-15 years old) continued to suffer from migraines as adults. Children who suffer from migraines report a significant decline in their quality of life compared to their healthy, non-migraine peers, such that they experience more absences from school, a decline in the amount of enjoyable activities they engage in, and more anxiety and depression (Powers, Patton, Hommel, & Hersehy, 2004; Powers, Patton, Hommel, & Hershey, 2003; Hunfeld, Passchier, Perquin, Hazebroek-Kampschreur, van Suijlekom-Smit, & van der Wouden, 2001; Guidetti, Galli, Fabrizi, Giannantoni, Napoli, Bruni, & Trillo, 1998; Abu-Arefeh & Russell, 1994; Breslau & Davis, 1993).

There is similarly a high number of children who experience sleep difficulties (problems due to poor sleep quantity and/or poor sleep quality) in the general population. The overall prevalence of sleep problems that occur between infancy and adolescence is approximately 20-30 percent (Mindell, 1993). Inadequate amounts of sleep typically result from the inability to fall asleep or the inability to fall back asleep once awoken at night. Not only may a child's lifestyle contribute to the lack of necessary sleep (e.g. later bedtimes, excessive homework, television, poor-limit setting by parents, and co-sleeping with parents or siblings), but the presence of nighttime fears, anxiety, depression, or hyperactivity may also result in poor sleep quantity (Mindell & Owens, 2003; Muris, Merckelbach, Gadet, & Moulaert, 2000; Owens, Spirito, McGuinn, & Nobile, 2000; Owens et al., 1999; King, Ollendick, & Tongue, 1997). Poor sleep quality or fragmented sleep is usually attributed to night awakenings that may result from sleep-disordered

breathing, co-sleeping habits, nightmares, environmental factors, or periodic limb movements (Mindell & Owens, 2003).

Like pediatric migraine, inadequate sleep quality or sleep quantity also negatively impacts a child's quality of life. Studies indicate that sleep problems are associated with cognitive deficits, such as learning, speech, and language delays in children (Kaemingk et al., 2003; Mitru, Millrood, & Mateika, 2002; Sadeh, Gruber, & Raviv, 2002; Dearing, McCartney, Marshall, & Warner, 2001; Fallone, Acebo, Arnedt, Seifer, & Carskadon, 2001; Hansen & Vandenburg, 2001; Randazzo, Muehlbach, Schweitzer, & Walsh, 1998). In addition, studies suggest that an increase in behavioral problems (Gottlieb et al., 2003; Bates, Viken, Alexander, Beyers, & Stockton, 2002) and emotional disturbances (depression, anxiety) (Paavonen, Solantaus, Almqvist, & Aronen, 2003) are associated with sleep problems in children. Even a change in a child's sleep schedule by one hour (decrease or increase) can change a child's level of alertness and sleep quality (Sadeh & Raviv, 2003). Moreover, changes in sleep patterns have also been predictive of less adjustment in school (Bates et al., 2002).

Research indicates that children with migraine experience rates of sleep problems at least twice that of the general population (Miller, Palermo, Powers, Scher, & Hershey, 2003; Bruni et al., 1997). Fatigue and yawning were more commonly observed in Finnish children suffering from migraines than were phonophobia, photophobia, and nausea, which are the primary classification symptoms of migraine (Aromaa, Sillanpaa, Matti, Rautava, & Helenius, 1998). Pediatric migraine sufferers report significantly shorter sleep duration, a longer sleep onset delay, greater bedtime resistance, more daytime sleepiness, more awakenings at night, more sleep-related anxiety, more parasomnias (i.e. physiological changes or behavior that occur while a child is asleep), more sleep-disordered breathing, more co-sleeping habits, and more bruxism (i.e. teeth grinding) compared to their peers (Miller, Palermo, Powers, Scher, & Hershey, 2003; Bruni et al. 1997). Migraine children also exhibited poorer sleep hygiene, such that their bedtimes were later than 11:00, they woke up after 8:00, took daily naps frequently, reported inconsistent bedtime and wake time schedules during the week, consumed caffeinated drinks before bedtime, and used drinks or medications to help them fall asleep (Bruni, Galli, & Guidetti, 1999). The frequency of sleep disturbances among children

with migraines is strongly supported in the emerging literature, emphasizing the importance of understanding why these two disorders co-occur.

Understanding the Presence of Comorbidity

Given the adverse effects of pediatric migraine and sleep problems individually on quality of life, it is important to investigate further why these two medical disorders co-exist in many children, because of the likely incremental adverse effect on quality of life that these disorders may create. Although several studies have established the existing comorbidity between sleep and migraine in the pediatric population and concluded that that sleep problems are more prevalent in children with migraines compared to healthy, migraine-free children (Miller et al., 2003; Bruni et al., 1997), only a handful of studies have attempted to investigate the reasons for this comorbidity. While some studies find an association between pre-existing sleep problems and later development of migraine (Bruni et al., 1999; Aromaa, Rautava, Heleneius, & Sillanpaa, 1998; Bruni et al., 1997), other studies found that migraine attacks were associated with later sleep disturbances (Miller et al., 2003; Neveus, Crattingius, Olsson, & Hetta, 2001). Moreover, Bruni and colleagues utilized an objective sleep measure (actigraphs) to measure sleep characteristics during migraine and non-migraine attacks and found motor activity during sleep to be the lowest the night preceding a migraine attack, which supports the pathophysiology of migraine and suggests that sleep and migraine may be a result of common, underlying, physiological changes in the body as opposed to one disorder causing the other (Bruni, Russo, Violani, & Guidetti, 2004). However, many of these studies are descriptive in nature and therefore do not adequately address causality, leaving an unclear understanding of why children with migraine exhibit more sleep disturbances than their peers.

One hypothesized explanation for the comborbidity of pediatric migraine and sleep disturbances is that children with migraine exhibit a dysfunctional autonomic nervous system characterized by an exaggerated stress response followed by a prolonged return to homeostasis, which makes these children more susceptible to migraine attacks as well as sleep disturbances. Only a handful of studies have assessed autonomic functioning in children with migraine, and the results have been inconclusive. Yakinci and colleagues (1999) found that children with migraine exhibited significantly higher

systolic (SBP) and diastolic (DBP) blood pressure in the upright position during an orthostatitic test than when lying down, while the control group's SBP and DBP were significantly higher in the supine position compared to the upright position. The authors also found that the migraine group displayed a higher mean difference in SBP than the control group during the sustained handgrip test. Moreover, the migraine group exhibited significantly higher Valsalva ratio and 30/15 ratio compared to the control group. The authors conclude that these results indicate ANS dysfunction characterized by hyperactivity of the sympathetic nervous system (SNS) system.

Herman and Blanchard (1998), on the other hand, found no significant differences in autonomic arousal (as measured by heart rate, skin-conductance, and finger temperature) at rest or after either a subtraction task or parent-child conflict stressor. The lack of studies investigating the dysregulated ANS hypothesis along with different methods of studying ANS activity leaves researchers with unanswered questions. More research is needed to determine whether the stress response system of children suffering from migraines may be more reactive to stressors and take longer to recover from a stress response than is true for healthy peers.

While there is a dearth of research addressing the question of dysregulated ANS systems and reactivity to stress, the pediatric migraine literature does indicate that stress is associated with migraine attacks. Stress is commonly identified as a precipitating trigger of migraine attacks (Blau & Thavapalan, 1988; Osterhaurs & Passchier, 1992; Passchier & Orlebeke, 1985). Moreover, children and adolescents with a history of headaches (e.g. migraine, tension, or combined headache) report more stress than their healthy peers (Waldie, 2001; Kowal & Pritchard, 1990; Passchier & Orlebeke, 1985). A study investigating the prevalence of headaches in children before and after school entry found that there was a 20 percent increase in the prevalence of headaches after the first six months of school compared to the months prior to school entry (Anttila, Metsahonkala, & Sillanpaa, 1999). This finding implies that the increase in stress related to school performance and the changes in sleep quality and quantity during school may precipitate headaches in children.

Family stress has also been associated with migraine. Anttila and colleagues (2000) conducted a follow-up evaluation of the children in their study who experienced

headaches six month prior to the beginning of preschool and found that family stress and unhappiness predicted migraine occurrence at 8-9 years of age (Antilla et al., 2000). Stress in the form of mental disorders has also been associated with pediatric migraine. Breslau, Davis, & Andreski (1991) found that children who experienced migraines in childhood suffered from anxiety before the occurrence of migraines, and they also experienced depression one year after the onset of migraines. Kowal and Pritchard (1990) found that both anxiety and stress predicted the pain severity of migraines in children. Guidetti and colleagues (1998) found that children with migraine who experienced anxiety disorders were likely to exhibit migraines eight years later compared to those children who did not exhibit anxiety symptoms. Given that children with migraine experience more stress than their peers, it is plausible that the increase in stress leads to a dysregulation in autonomic functioning that makes these children more vulnerable to further stress and medical disorders.

In order to better understand the role of abnormal physiological processes that may lead to migraine and sleep difficulties, it is beneficial to review briefly the most current theory of migraine pathophysiology. The spreading activation theory (Moskowitz, 1993) regarding the pathophysiology of migraine proposes that migraine attacks are triggered by either external stressors (e.g. stress, exercise, etc.) or internal physiological changes that initiate a cascade of neurochemical changes in the cerebral cortex that alters blood flow in the brain. Fibers from the trigeminal neurons that extend to the meninges (the inside lining of the skull) respond to these neurochemical changes in the cortex by releasing neurochemicals casuing dilation of the blood vessels. This inflammatory response is cyclical because the dilation of the blood vessels results in the release of more vasoactive compounds from the vessels, which perpetuates the vessel dilation. Furthermore, these physiological events are interpreted in the sensory cortex as intense pain (Peroutka, 2004; Waeber & Moskowitz, 2003; Bolay et al., 2002; Sanchez del Rio & Moskowitz, 2000; Hammel, 1999; Moskowitz, 1993).

If children with migraine do exhibit a greater stress response than their peers, their body may also take longer to recover from the stressor. If frequent encounters with stress occur, these children would likely be more sensitive to future stressors because they would have a lower threshold to initiate the stress response than their peers. This chronic

activation of the stress response system could result in a dysregulation between the sympathetic nervous system (SNS) and the parasympathetic nervous system (PNS) such that the SNS would dominate (Yakinici et al., 1999). This dysregulated autonomic nervous system (ANS) could cause the cerebral cortex to become more sensitive, thereby initiating the neurochemical changes that precipitate a migraine attack. If stress and a disrupted ANS are associated with migraine attacks, these factors may also precipitate changes in sleep.

While there are no known studies assessing how stress affects sleep quality and ANS functioning in children, research has indicated that ANS functioning changes during sleep. In healthy children parasympathetic activity increases from the onset of sleep through the night and peaks during the deep stages of sleep while sympathetic activity is at its lowest during deep sleep stages but increases during REM and during wakefulness (Villa et al., 2000; Baharav et al., 1995; Vaughn et al., 1995). Moreover, the adult literature has found that stress results in decreased parasympathetic modulation and increased sympathetic activation during deep sleep, which was associated with an increase in frequent night awakenings and less time spent in deep sleep (Hall et al., 2004). In addition, pediatric research indicates that reported stress associated with school (Wolfson & Carskadon, 1998 Wolfson, 1996; Carskadon, 1990), family (e.g. hospitalizations, divorce, moving, fights, etc.; Sadeh, Raviv, & Gruber, 2000), and mental illness (e.g. anxiety-related disorders, depression, PTSD; Sadeh, 1996; Fisher & Rinehart, 1990; Moore, 1989) is associated with poorer sleep quality and increased sleep problems. Interestingly, a pediatric study also found that children with anxiety disorders exhibited an increase in their SNS functioning at rest compared to non-anxious children (Yeragani et al., 2001). These few studies imply that children who experience stress, whether it be in the form of external stressors (e.g. school or family) or internal stressors (e.g. presence of mental disorder), exhibit a dysregulation in their ANS functioning characterized by a predominance of sympathetic activity that may also disrupt sleep quality.

Although limited, the available pediatric research on the relation among pediatric migraine, sleep disturbances, and stress is promising and warrants further investigation. In order to clarify whether a dysregulated ANS system underlies the relation between

pediatric migraine and sleep, improvements in the measurement of ANS functioning are needed. The inconclusive findings in the pediatric literature regarding autonomic functioning may be a result of researchers using imprecise physiological measures, such as blood pressure and heart rate, to assess autonomic functioning. Heart rate and blood pressure measurements cannot determine ANS disruption because they are affected by both the SNS and PNS activity simultaneously (Rhodes, Harrison, & Demaree, 2002). Moreover, undetected differences in autonomic functioning, such as found in Hermann and Blanchard (1997)'s study, may be due to the children exhibiting simultaneous changes in both the SNS and PNS systems (Rhodes et al., 2002). Physiological measurements that obtain separate measurements of sympathetic activity and parasympathetic activity would allow for more specific assessments and more reliable conclusions.

Improving our Knowledge Base: The Role of Heart Rate Variability.

Heart rate variability (HRV), a measurement of changes in the length of time between normal heart beats, provides a measure of both parasympathetic activity (HF index) and sympathetic activity (LF index) as well as the dynamic interaction between the two branches of the ANS (Task Force, 1996). HRV, therefore, provides significant improvements in researchers' abilities to assess the ANS disruption hypothesis in children. While HRV can be measured in several ways, the Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology (Task Force, 1996) recommend that the frequency domain indices be used to measure short-term recordings of HRV. The frequency domain indices assess how much of the variability in the heart's rhythm is due to the changes in heart rate at different frequencies and are derived using an algorithm that transforms the time domain wavelengths into the frequency domain (Lathi, 1992). The three main frequencies that are measured in the frequency domain include the very low frequency (VLF), low frequency (LF), and high frequency (HF). Research indicates that the VLF, (frequency range of .003-.04 HZ) is associated with the temperature regulation, the LF (frequency range of .04-.15 HZ) is likely a measure of both sympathetic and parasympathetic activity, and HF (frequency range of .15-.4), which is also referred to as the respiratory sinus arrhythmia (RSA), is associated with respiration and is considered a measure of parasympathetic activity (Task

Force, 1996). The ratio of LF/HF can be used as a measure of balance between the sympathetic and parasympathetic balance.

HRV has been used to measure ANS functioning in normal, healthy children during sleep (Pivik, Busby, Gill, Hunter, & Nevins, 1996) and while awake (Finley & Nugent, 1995) as well as with children suffering from a variety of medical disorders, including diabetes (Riihimaa et al., 2002), anxiety related disorders (Monk et al., 2001), epilepsy (Ferri et al., 2002), and congenital heart disease (Heragu & Scott, 1999). Studies of HRV in children have demonstrated that HRV differs across age groups (Kazuma, Otsuka, Wakamatsu, Shirase, Matsuoka, 2002; Silvetti, Drago, & Ragonese, 2001; Massin & Bernuth, 1997; Finley & Nugent, 1995) and between healthy children and children with various medical conditions and emotional difficulties (Scheeringa, Zeanah, Myers, & Putnam, 2004; Riihimaa, Supminen, Knipt, Tapanainen, & Tolonen, 2002; Ferri et al., 2002; Monk et al., 2001; Vill et al., 2000; Heargu & Scott, 1999). Furthermore, studies indicate that HRV changes in response to various stressors, including physiological stressors (e.g. C02 inhalation and physical exercise; Winsley, Armstrong, Bywater, & Fawkner, 2005; Mandigout et al., 2002; Monk et al., 2001) and emotional stressors (e.g. completing narratives with an emotional theme; Barh-Haim, Fox, VanMeenen, & Marshall, 2004). To the best of the author's knowledge, HRV measures of children with migraine have not been documented in the literature and therefore would provide valuable information regarding the physiological functioning of this pediatric population.

Purpose of Study.

Understanding why the relation between sleep and migraine exists will help researchers and clinicians integrate psychological and biological aspects of medical disorders in order to improve the conceptualization of these medical problems. By recognizing the need to assess for and treat comorbid psychological and biological problems among patients suffering from medical disorders, clinicians should be able to improve efficacy of treatment and improve the overall quality of patients' lives.

The primary aims of this study were threefold. First, we investigated whether children with migraine experience more sleep problems, stress, and anxiety than their healthy peers. Secondly, the autonomic nervous system functioning in children with

migraine was compared to a healthy peer group at rest, in response to a stressor, and during recovery from a stressor. It was hypothesized that the LF/HF ratio at rest and in response to a personal stressor will be significantly higher in children with migraine than the healthy peer control group. It was also hypothesized that during the recovery period, the mean change in the LF/HF ratio will be significantly larger in the control group than the migraine group because the ratio will return to the baseline level in the control group but not in the migraine group. Finally, the study investigated whether the difference in sleep disturbance between the migraine group and the peer control group was mediated by a disrupted autonomic nervous system.

Chapter Two

Methods

Setting and Participants

The participants in the study were 21 children with migraines (11 females, 10 males) and 32 comparison children (15 females, 17 males), ranging in age from 7 to 12 years. The members of the migraine group were recruited from two locations. 16 children were recruited from the Neurology Clinic at the University of Kentucky in Lexington, Kentucky, and 6 children were recruited from advertisements in the local newspaper. One child who was recruited from neurology was excluded from the analyses because he was 13 years old; therefore, a total of 15 children were recruited from neurology and 6 from the newspaper. For participants in the migraine group to be included in the study, they had to meet the International Headache Society's criteria (IHS) for migraine that has been adapted for children (Table 2.1; Winner, Wasiewski, Gladstein, & Linder, 1997) as diagnosed by a neurologist or other medical doctor and by a screening questionnaire completed before the start of the study.

Of the total children in the control group, 28 were recruited from an advertisement in the local newspaper while 7 children were recruited from flyers posted in the local hospital. Two of the children recruited from the newspaper were excluded because one indicated on paperwork a history of seizures and one was 13 years old. One child recruited via the flyers was excluded because the information forms indicated that he experienced a history of seizures; therefore resulting in a total of 26 recruited from the newspaper and 6 from flyers.

The exclusion criteria for both the migraine and comparison groups were: 1). A diagnosis of any neurological disorder (e.g. seizures); 2). A diagnosis of hypertension; 3). A diagnosis of any cardiovascular disease or defect; 4). A diagnosis of diabetes; or 5). A diagnosis of asthma requiring daily prescribed medication for asthma management. The control group was comparable for age and sex, and did not have a history of migraine as determined by a questionnaire based on the IHS criteria. Participants were paid $25 for their participation in this study. Informed consent was obtained from both the children and their legal guardian.

Table 2.1 IHS Criteria for Migraine

Migraine without Aura

A). At least five migraine attacks fulfilling the B, C, and D.

B). Headaches last 1-48 hours without treatment.

C). Headache has at least two of the following:

1). Bilateral (frontal/ temporal) or unilateral location

2). Pulsating quality

3). Moderate to severe intensity

4). Aggravated by routine physical activity

D). During the headache, at least one of the following is present:

1). Nausea or vomiting

2). Sensitivity to light (photophobia) or sensitivity to sound (phonophobia)

E). Absence of organic disease

Migraine With Aura

A). At least two attacks fulfilling the B criteria.

B). At least three of the 4 following characteristics:

1). One or more fully reversible aura symptoms indicating focal cerebral cortical and/or brain stem dysfunction.

2). At least one aura symptom develops gradually over more than 4 minutes or, 2 or more symptoms occur in succession

3). No aura symptom lasts more than 60 minutes. If more than one aura symptom is present, accepted duration is proportionally increased.

4). Headache follows aura with a free interval of less than 60 minutes but may begin before or simultaneously with the aura.

(Winner, Wasiewski, Gladstein, & Linder, 1997).

There were no significant differences between the comparison and migraine groups on any of the demographic variables except mother's education. Mothers of the migraine children completed significantly fewer years of schooling compared to the mothers of the control group (See Table 2.2). In order to determine whether the difference between the comparison and migraine groups in regards to mother's education would confound the results, mother's education was correlated with the dependent variables. Results indicated that mother's education was only significantly related to Parenting Stress Inventory Total raw score ($r=-.30$, $p<.05$). However, the results of the analyses were not different when mother's education was entered as a covariate from when it was left out of the analyses. As a result, results are presented without the covariate for ease of interpretation.

Within the migraine group, all of the 21 children included in the analyses met criteria for migraine according to the International Headache Society criteria (Winner, Wasiewski, Gladstein, & Linder, 1997) whereas none of the 32 children in the control group met criteria for migraine. In fact, only 2 of the children in the control group reported a history of any head pain and this pain was related to sinus problems. Therefore, the migraine sample is a valid representation of pediatric migraine and the control group is not.

Within the migraine sample, the average age of the initial migraine onset was 7.81 years (1.78 SD). The average frequency of migraines was 5.47 months (SD 8.47) with the average reported pain of the attacks being 4.71 (SD 1.93) on a scale of 0-10 (10=worse pain ever) and the average severe pain being 8.10 (SD 1.95). The average duration of the migraine attacks was 7.59 hours (SD 8.89 hours). 50% of the children in the migraine group experienced an aura preceding their migraine attacks. 81% of the sample reported unilateral head pain while 19% described bilateral head pain and all of the children in the sample described their head pain as pulsating. 75% of the sample reported that increase in physical movement exacerbates their pain, 72% reported nausea during their migraine attacks, and 10% reported stomach problems with their migraine attacks. 90% of the migraine sample reported sensitivity to light while 85% stated a sensitivity to sound. 67% of the sample reported a family history of migraine.

Table 2.2 Descriptive Statistics Between Comparison and Migraine Groups

Variable	Migraine(n=21)	Comparison (n=32)
Ethnicity		
White(%)	100	78.13
African-American(%)	0	12.5
Hispanic(%)	0	3.13
Biracial (%)	0	6.25
Gender	n=10 boys	n=17 boys
Age (in years)	10.10 (1.34)	10.28 (1.20)
Grade (%)		
2nd	4.76	3.13
3rd	19.05	12.5
4th	19.05	15.63
5th	28.57	31.25
6th	19.05	25
7th	9.52	12.5
Marital Status (%)		
Married	80.95	59.38
Divorced	9.52	12.5
Single	9.52	21.88
Separated	0	3.77
Mother's Education [M (SD)]**	14.48 years (2.36)	16.56 years (1.87)

** $p<.01$

Dependent Measures

Psychological Measures

Demographic Form. Participants were asked to complete a demographic form that asked for information on age, gender, ethnicity, grade in school, and mother's educational status, (See appendix 1).

Medical History Questionnaire. Participants completed a medical history questionnaire that asked about the child's health history, current and past medications, as well as specific questions related to symptoms of migraine (See appendix 2).

The Faces Pain Scale-Revised. The Faces Pain Scale- Revised (FPS-R) is a self-report questionnaire for ages 4 years to 16 years of age that measures intensity of pain (Hicks, von Baeyer, Spafford, van Korlaar, & Goodenough, 2001) and was used to assess pain intensity in the migraine group for descriptive purposes. The measure consists of six faces representing the amount of pain experienced with the face farthest to the left representing no pain (score of 0) and the face farthest to the right representing the worst pain (score of 10). Children are asked to circle the face that shows how much they hurt right now. The FPS-R has been shown to be highly correlated with visual analog scales (r = .93 (Hicks et al., 2001). Moreover, the faces were correctly ordered by both younger (62%) and older children (75%), and had good retest reliability one week later (86% for younger children and 71% for older children) (Bieri, Reeve, Champion, Addicoat, & Ziegler, 1990).

Children's Sleep Habits Questionnaire. The Children's Sleep Habits Questionnaire (CSHQ) was used to assess sleep behaviors observed during a typical week (Owens, Spirito, & McGuinn, 2000). This parent-report measure consists of 45 items that generate an overall total score, which measures total sleep disturbance, and eight subscales that assess specific clinically significant sleep problems found in school age children including bedtime resistance, sleep onset delay, sleep duration, sleep anxiety, parasomnias, sleep-disordered breathing, daytime sleepiness, and night wakings. Parents rate the frequency of sleep behaviors on a three-point Likert scale: usually (5 to 7 times per week), sometimes (2 to 4 times per week), or rarely (0 to 1 times per week). The CSHQ has adequate internal consistency for the total sleep disturbance scale among a community sample (α=.68) as well as a clinical sleep disorders sample (α=.78). Test-

retest reliability was also acceptable (.62-.79) and the measure was effective at differentiating between children with sleep disorders and healthy children (Owens, Spirito, & McGuinn, 2000). In the present study, the internal consistency for the total sleep disturbance scale among the total sample was .78. The internal consistency for the subscales range from .36 to .70 for the community sample and from .56 to .93 for the clinical sample (Owens, Spirito, & McGuinn, 2000), while the internal consistency for the subscales in this study ranged from .55-.75.

Parenting Stress Index (PSI). The PSI is a 120-item screening tool completed by the parent that provides a rating of the stress level surrounding the parent and the child relationship (Abidin, 1995). The measure can be used with children between the ages of 1 and 12 years and assesses the stress level by evaluating the child characteristics, parent characteristics, and situational/demographic life stress events. The Child Domain scale consists of six subscales that assess ways in which the child may affect the child-parent relationship: Adaptability (AD), Acceptability (AC), Demandingness (DE), Mood (MO), Distractibility/Hyperactivity (DI), and Reinforces Parent (RE). The Parent Domain scale consists of seven subscales that assess ways in which parent characteristics influence the parent-child relationship: Depression (DP), Attachment (AT), Role Restriction (RO), Competence (CO), Isolation (IS), Spouse (SP), and Health (HE). The PSI has excellent internal consistency for each of the domains: (Child Domain (.90), Parent Domain (.93), Total Stress (.95). The subscales within each domain are also good, ranging from .70 (MO and HE) to .84 (DP). Test-retest reliability of the PSI has been demonstrated as well with the correlation coefficients between the first administration and the second administration 1-3 months later being .63 for the Child Domain, .91 for the Parent Domain, and .96 for the Total Stress score (Abidin, 1995). The PSI has been used to assess stressful parent-child relationships among children with developmental disorders, health problems, and behavior problems as well as to predict children's outcome in treatment and a mother's psychological adjustment (Abidin, 1995). In this particular study, the internal consistencies for the scales were as follows: .94 for the total PSI scale, .91 for the Parent Domain, .90 for the Child Domain subscale, and .57 for the Life stress. The subscales range from .51(AT) to .85 (AD).

Multidimensional Anxiety Scale for Children (MASC). The Multidimensional Anxiety Scale for Children (MASC) is a 39 item self-report instrument used to measure anxiety symptoms in children age 8 to 19 years who have at least a fourth grade reading ability (March, 1997). In addition to an overall measure of anxiety (Total Anxiety) and two major indices (Anxiety Disorder and Inconsistency), the scale is comprised of four basic scales: Physical Symptom, Harm Avoidance, Social Anxiety, and Separation/Panic. The internal consistency of the Total Anxiety scale in children ages 8 to 11 years is good (.87) while the internal consistency for the Anxiety Disorders Index is adequate (.60). The internal consistency for the four subscales ranges from .81 (Physical Symptoms) to .61 (Harm Avoidance). Test-retest reliability for the Total Anxiety scale is good (.93) as well as for the subscales (.93- .72). The discriminate validity of the MASC in identifying children with an anxiety disorder from those without an anxiety disorder is good with a sensitivity rate of 90%. Within this sample, the internal consistency for the overall MASC Score was .79 while the subscales ranged from .60-.74.

Physiological Measures

The physiological data were collected using the MP100 Biopac data acquisition system (Biopac Systems, Inc.). The configuration for this study included the following modules: electrocardiogram, respiration transducer, and peripheral blood flow modules. The sampling rates for each configuration were set according to the recommendations in the MP100 Biopac manual. Blood pressure was measured using a hand-held blood pressure machine.

Electrocardiogram (ECG). Cardiovascular activity was recorded using three Ag/AgCl electrodes using shielded leads connected to an ECG100C Electrocardiogram Amplifier. The electrodes were placed in the crook of each elbow and the ground was placed on the back of the neck.

The HRV frequency domain indices were calculated by initially filtering and then transforming the ECG signal into R-R intervals using the Biopac Acquire System Software. These data were then saved as a text file for the frequency domain analyses. The Frequency domain analyses were then completed using the HRV Analysis software version 1.1SP1 by Biomedical Signal Analysis Group, Department of Applied Physics, University of Kuoplo, Finland. This study reports the non-parametric Fast Fourier

Transform (FFT) HRV values generated by this program in normalized units, including Low frequency index (LF), High frequency index (HF), and LF/HF ratio.

Peripheral blood flow. Peripheral blood flow was measured with a transducer (TSD200) placed on the middle finger of the non-dominant hand. This transducer provided a pulse pressure waveform signal to the PPG100C amplifier. This signal consisted of changes in infrared reflectance resulting from varying blood flow. Placement on the finger provided a measure of change in peripheral vasoconstriction.

Respiration Transducer. Respiration was measured with a respiration transducer (TSD101B) that was connected to the RSP100B respiration pneumogram amplifier module to measure abdominal respiration. The respiration transducer was placed around the abdomen and measured abdominal expansion and contractions.

Blood Pressure Machine. A portable blood pressure machine was used to measures participant sitting blood pressure and pulse. The monitor was Intelli Sense-Omron Digital Blood pressure monitor with Fuzzy logic Hem-737. The blood pressure cuff was placed on the participant's nondominant upper arm.

Emotional Arousal

All participants participated in an emotional arousal task while the physiological data were recorded. The emotional stimulus consisted of describing in detail a past stressful, negative event. The first half of the Social Competence Interview (SCI; Ewart & Kolodner, 1991) was used to illicit the emotional stimulus. During the first two minutes of the emotional stimulus, the participants were handed six index cards that each described problems in specific areas (e.g. family, school, friends, money, neighborhood) that are commonly experienced by preadolescents and adolescents. The participants were then asked to sort the cards according to the least stressful area to the most stressful area in his/her life and to remove any items that he/she did not wish to discuss. The examiner then asked the participants to describe in detail for eight minutes a stressful event that occurred in the area that was chosen by the child as the most stressful area. The SCI has been shown to be a non-threatening laboratory stressor that elicits greater blood pressure changes in adolescents and preadolescent children than other common laboratory stressors (e.g. video games, mental arithmetic, and mirror drawing) (Chen, Matthews, Salomon, & Ewart, 2002; Ewart & Kolodner, 1991).

Procedure

The child and his/her legal guardian signed an informed assent/consent. The participants were next asked to complete the packet of questionnaires (demographic questionnaire and the MASC) while their legal guardian completed the parent-report measures (PSI, CSHQ). The children and their legal guardians who were recruited as the control group also completed the same standard packet of questionnaires.

The physiological assessment was conducted in a quiet, therapy room located on campus. The temperature in the room was maintained at approximately 71 degrees Fahrenheit. The participants were asked to sit comfortably in a chair facing the examiner. The examiner was present in the room at all times. During the physiological assessment, the participants were attached to several electrodes that assessed the different physiological measures. The examiner explained to the participants that the instruments measure what the body is doing. As the examiner hooked each participant up to the equipment, the examiner explained the function of each piece of equipment and ensured the children that the equipment did not hurt. Once the participants were attached to the physiological measures, they were asked to sit quietly for two minutes while they habituated to the equipment and environment. Next, the participants were instructed to remain still and calm and to try to relax during the Baseline Period (5 minutes). The Emotional stimulus period (15 minutes) was then administered using the adapted Social Competence Interview. During the Recovery period (5 minutes), the participants were thanked for sharing an upsetting problem and were asked to sit quietly and try to relax. At the conclusion of the study, the equipment was unhooked from the participants and they were asked to describe their favorite food and a time when they were eating this food in order to aid in invoking a positive mood at the conclusion of the study. At the conclusion of the study both the participant and the caregiver were debriefed.

The primary psychological dependent variables that were analyzed for this study were MASC total raw score, CSHQ total score, and PSI total score. The primary physiological dependent variables were mean finger temperature, systolic and diastolic blood pressure, pulse, mean respiration rate, and LF/HF ratio. These physiological variables were measured at the end of each of the three study phases (Baseline, Emotional Stimulus, and Recovery Periods). The physiological data that were either

missing or were outliers due to measurement malfunctions were replaced by the average of that particular physiological measurement across the entire sample for that time period. The LF/HF ratio was analyzed by transforming the heart rate data over time as measured by the ECG using the FFT transformation method (Task Force, 1996). Due to significant problems in the recording of the respiration data due to mechanical failure of the transducer and artifact created by participant movement, the respiration data were excluded from analysis.

Chapter Three

Results

Manipulation Check

In order to determine if the Social Competence Interview (SCI) successfully created an increase in stress within the overall sample, two manipulations checks were undertaken. First, a paired samples *t* test was conducted on the subjective ratings of the children regarding their level of stress, comparing the differences in stress ratings among the baseline, stress, and recovery phases (see Table 3.1). Results revealed that there were significant differences in subjective stress ratings across all three time comparisons, indicating that the children's stress increased significantly after the stress condition and then declined at the end of the recovery period to a rate lower than was rated at the start of the study. The second manipulation check involved paired t tests for all of the physiological variables (pulse, mean temperature, diastolic blood pressure, systolic blood pressure, HF, LF, and LF/HF ratio) to determine whether these variables significantly changed across the different time periods (see Table 3.1). The results indicated significant changes in mean temperature from baseline to stress and from baseline to recovery such that the average change in hand temperature increased significantly from baseline to the end of the stress period as well as from baseline to the end of the recovery period. In addition, results indicated that there were significant changes in LF/HF ratio from baseline to stress phase and from stress to recovery phase, indicating that the LF/HF ratio increased significantly from baseline to stress phase and then decreased significantly from baseline to recovery. A higher ratio value suggests a more sympathetically driven system that is expected during a stressful encounter as is the case from the baseline to stress period (Task Force, 1996). A reduction in the ratio from baseline to recovery suggests the body is becoming more driven by the parasympathetic nervous system, which is expected after coping with a stressor. These results indicate that the use of the SCI as an emotional stressor was successful.

Having established the validity of the stressor task, three univariate ANOVAs (migraine group versus comparison group) were conducted to assess the first hypothesis that children with migraine will exhibit more sleep problems, anxiety, and stress compared to their peers. Results indicated no significant differences between groups on

Table 3.1 Manipulation Check for Social Competence Interview

	Bsln-Stress			Stress-Recovery			Baseline-Recovery		
	M	*SD*	t	*M*	*SD*	*t*	*M*	*SD*	*t*
Subjective Ratings	.79	1.26	4.64**	1.81	1.89	5.45**	.53	1.19	2.44**
Pulse	81.65	12.85	.48	82.33	14.20	1.60	78.27	17.02	1.40
Temperature	90.39	4.03	3.35**	91.16	4.12	1.81	91.65	4.08	3.87**
Diastolic BP	71.10	11.30	1.89	74.1	9.90	1.69	71.16	12.25	.04
Systolic BP	105.12	11.27	1.50	107.73	11.86	1.31	105.37	10.19	.16
LF/HF Ratio	.80	.63	4.79**	1.42	1.07	3.65**	.91	.65	1.46

** $p<.01$

the CSHQ total score, F(1,50)=.385, p=.54 or on the PSI total raw score, F(1,50)= 2.96, p=.06. However, there was a significant difference between groups on the MASC total raw score, F(1,50)=8.37, p<.01, Cohen's d= .73, such that the migraine group reported higher total anxiety scores, M=53.57, SD= 11.29, than the comparison group, M=45.09, SD= 11.70. Given these results, it appears that the children with migraine in this study exhibited more overall anxiety symptoms but did not report more sleep problems or stress problems compared to their peers.

In order to determine whether there is a relation between sleep disruption and migraine characteristics within the migraine group itself, Pearson correlations were calculated between migraine characteristics (migraine frequency, duration, and average pain intensity) with the CSHQ total score and subscales. Results revealed a significant relation between average pain and CSHQ total score (r=.44, p<.05) such that the greater the average reported pain of the migraine attack, the more sleep difficulties reported by the child's parent. In addition, average migraine pain was also significantly associated with the incidence of parasomnias (r=.44, p<.05), indicating that children with more rated average pain of migraine attacks experience greater incidence of parasomnias by their parent. Migraine duration was significantly related to night-time awakenings (r=.51, p<.05), such that the longer the average migraine duration, the more night-time awakenings are reported by their parents. Migraine frequency was not significantly associated with any of the CSHQ subscales or total score.

In order to assess hypothesis 2 that the migraine group will exhibit significantly different physiological changes at baseline, in response to the emotional stressor, and after a recovery period, a 2 (group) x 3 (time period) repeated measures ANOVA was conducted, analyzing the differences between the migraine group and the comparison group on the physiological variables across the three different time periods. Results (See Table 3.2) indicated a main effect for group only for pulse rate such that the average pulse rate in the migraine group was significantly higher (M=86.03; SD=2.83, Cohen's d=2.28) compared to the average pulse rate for the comparison group (M=77.29; SD=1.93). No other physiological variable significantly differed between the two groups. As a result of the differences between the two groups with regard to pulse rate, additional analyses were initially calculated using baseline pulse rate as a covariate; however, there

Table 3.2 Descriptive Statistics for Groups Across Time

		Baseline		Stress		Recovery	
		Mean	SD	Mean	SD	Mean	SD
Diastolic BP	Migraine	71.19	11.15	75.48	11.21	75.72	13.93
	Control	71.03	11.57	73.19	9.01	68.16	10.16
Systolic BP	Migraine	107.90	10.46	109.90	13.98	107.21	11.75
	Control	103.29	11.56	106.30	10.22	104.17	9.02
Stress Rating	Migraine	.48	.87	1.62	1.86	.10	.44
	Control	1.00	1.44	1.94	1.93	.81	1.42
Mean Temp	Migraine	90.29	4.55	91.01	4.65	91.26	4.77
	Control	90.46	3.73	91.25	3.81	91.90	3.62
Pulse **	Migraine	88.00	14.36	87.40	17.32	82.68	16.54
	Control	77.49	9.95	79.01	10.77	75.38	16.96
LF/HF Ratio	Migraine	.86	.42	1.68	1.44	1.09	.79
	Control	.79	.74	1.24	.72	.79	.53

** $p<.01$

were no differences in the results when baseline pulse was entered as a covariate and when it was not entered, therefore the rest of the results will be presented without the covariate in the analysis. The results exhibited a significant group by time interaction for diastolic blood pressure, $F(1,51)= 5.28$, $p<.05$ and a marginal group by time interaction for the LF/HF ratio, $F(1,51)= 3.75$, $p<.06$ as illustrated in Figures 4.1 and 4.2. Follow- up focused contrasts were calculated to further determine how the two groups differed by time with regards to DBP. The migraine and comparison groups exhibited similar DBP at both baseline and after the stressor but significantly differed at the end of the recovery period, $t(1,51)= 5.22$, $p<.05$, Cohen's $d= 1.46$. The migraine group exhibited a significantly higher DBP compared to the comparison group at recovery suggesting their DBP as a group did not recover as quickly after a stressor as their peers. A follow-up within subjects comparison revealed no significant difference in diastolic blood pressure between the stressor or recovery phase for the migraine group, $t(20)=.07$, $p=.94$, indicating the migraine group did not exhibit much of a recovery in diastolic blood pressure after an emotional stressor. On the other hand, there was a significant reduction in diastolic blood pressure from the stress phase to the recovery period for the comparison group, $t(34)=2.92$, $p<.01$. Visual investigation of the group by time interaction for the LF/HF ratio results suggests that the migraine and comparison groups exhibited similar baseline and stress measurements but that the migraine group exhibited a slightly higher response at the end of the recovery period. These results suggest that the migraine group may take longer to recover after a stressor. These results lend support to the premise that children with migraine exhibit a dysfunctional stress response system compared to their peers that causes these children to take longer for their bodies to recover from stressful encounters.

The third hypothesis, that HRV ratio mediates the relation between the presence of migraine and sleep problems, was not investigated given there was not a significant difference between the migraine and control group with regards to sleep.

Figure 3.1 Group x Time Interaction for Diastolic Blood Pressure

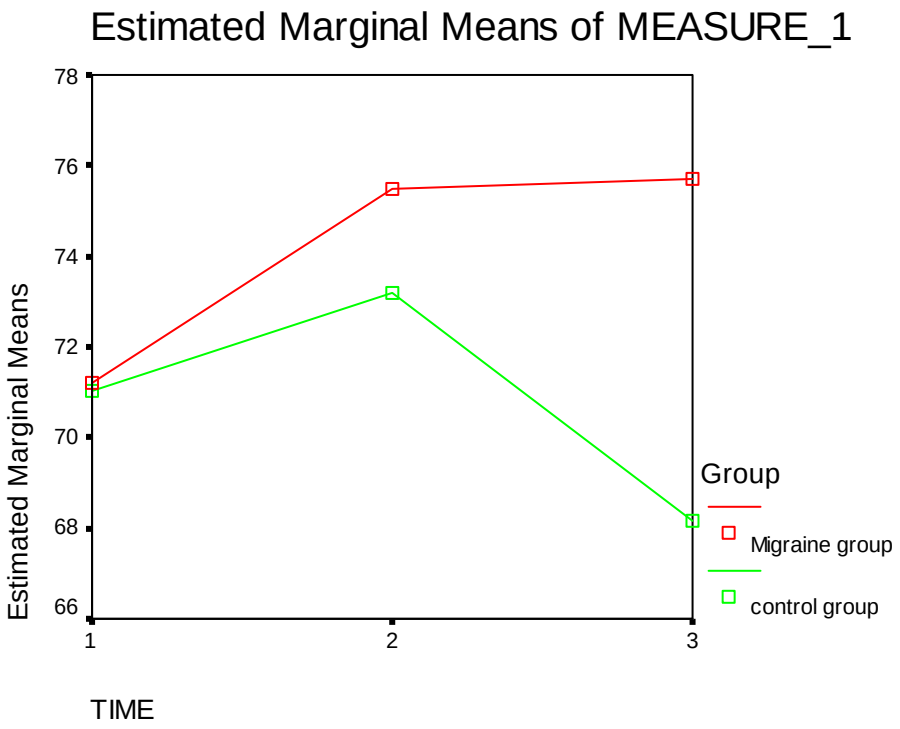
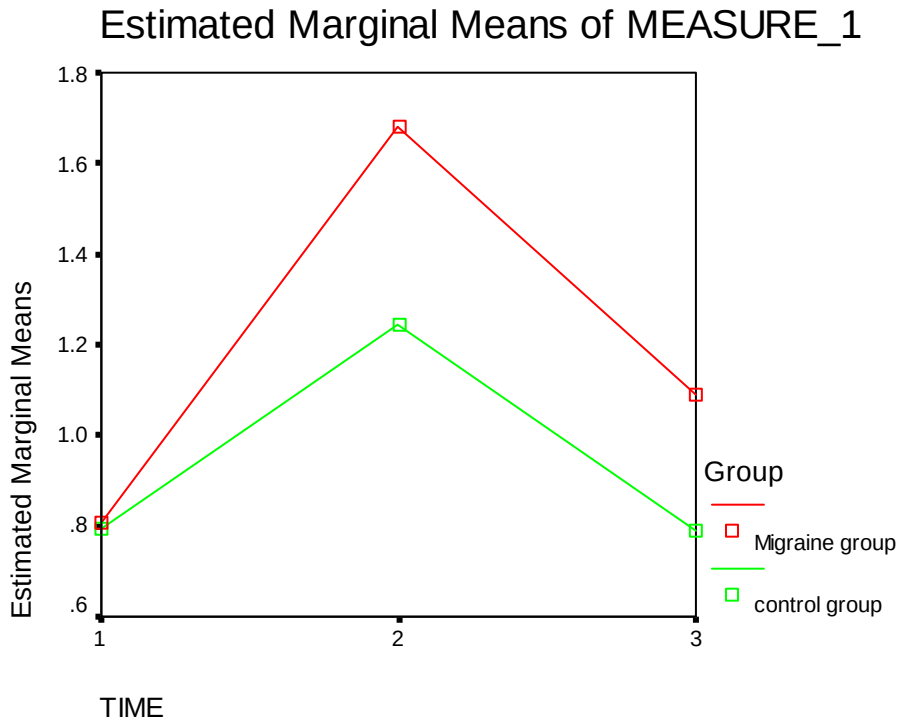


Figure 3.2 Group X Time Interaction for Ratio



Chapter Four

Discussion

General Discussion

This study compared prepubescent children diagnosed with migraine with their healthy, non-migraine peers on levels of sleep disturbance, anxiety, family stress, and physiological reactions to an emotional stressor. The main purposes of the study were to further investigate the relation between sleep difficulties and the presence of migraines in prepubescent children as well as the physiological differences between children with migraine and their peers both at rest and in response to a stressor.

In terms of parental reports of sleep difficulties, there were no significant differences between the two groups of children. However, within the migraine group itself there were a number of significant relations between migraine characteristics and sleep difficulties. Specifically, this study found that the reported average pain intensity of migraine attacks was significantly related to the parental report of overall sleep difficulties and with the incidence of parasomnias, such that higher pain intensity was associated with more sleep problems as well as a greater frequency of parasomnias. In addition, migraine duration was significantly associated with nighttime awakening, such that longer migraine attacks were related to an increase in awakenings at night. Thus, the results of this study further support research finding that within migraine children, migraine characteristics are significantly related to sleep difficulties. In contrast to the present results, Miller and colleagues (2003) did not find significant relations between migraine characteristics and the CSHQ total score and subscales, although there were significant associations between the characteristics and individual items of the sleep measure. This finding further supports the notion that sleep difficulties are in some way related to the presentation of migraine.

Despite this finding of significant within group correlations, the lack of significant differences between the migraine group and comparison group regarding sleep difficulties was surprising given previous research that suggested differences do exist (Miller et al, 2003). Given the small effect size for the main effect of group, it is unlikely that a larger sample size would result in a significant group difference in sleep difficulties. One possible explanation for the difference in findings between the two

studies is that the Miller et al. study consisted of children with more severe migraine symptoms than this study's migraine group. Moreover, the majority of the children in the migraine group in this study were taking medications for their symptoms whereas Miller et al.'s migraine group did not begin treatment at the time of the study. The medications taken by this study's migraine children may have improved sleep problems. Alternatively, group differences might have been obtained if sleep problems were rated by the children themselves as opposed to their caregiver. It is possible that caregivers are not aware of their children's sleep problems even at this young of an age. Future research may benefit from assessing sleep difficulties from both the perspective of caregivers and of the children themselves.

This study also found that children with migraine report significantly more anxiety than their peers according to their MASC ratings. This finding is consistent with previous research that has found children with migraine experience more psychiatric distress in general (Guidetti et al., 1998; Breslau & Davis, 1993; Breslau, Davis, & Andreski, 1991; Kowal & Pritchard, 1990). Individuals who suffer from anxiety may likely spend more time in a hypervigiliant state searching for danger, have trouble controlling ruminative thought patterns or worry, and may miss evidence that contradicts their anxiety-provoking beliefs, resulting in prolonged sympathetic activation compared to peers. Adult and child research on anxiety suggests that individuals who are diagnosed with anxiety disorders compared to their peers exhibit more sympathetic activation and greater disinhibition of the parasympathetic input (Scheeringa, Zeanah, Myers, & Putnam, 2004; Srinivasaan, Ashok, Vaz, & Yeragani, 2002; Monk, Kovelenko, Ellman, Sloan, Bagiella, Gorman, & Pine, 2001; Yeragani, Radhakrishna, Pohl, Jampala, & Balon, 2001; Thayer & Lnae, 2000; Thayer, Friedman, Borkovec, 1996).

The increased anxiety for the migraine group is interesting given the study's results investigating the physiological differences between the comparison and migraine groups. Specifically, the results revealed that although there were no significant group differences in heart rate variability data at baseline, children with migraine did exhibit a higher heart rate than their peers at baseline. This finding suggests that children with migraine may experience a greater sympathetic activation at rest and inhibition of parasympathetic activity. Yakinci and colleagues (1999) also found significantly higher

diastolic blood pressure in children with migraine compared to peers in the upright position on an orthastotic test. Children with migraine therefore may experience a disruption in autonomic functioning as theorized.

Although children with migraine do not appear to exhibit a greater stress response, as originally hypothesized, they may have difficulty recovering from stress as seen by the group by time interaction of diastolic blood pressure and the marginally significant effect of LF/HF ratio. These results imply that children with migraine have similar responses to stress as their peers but take longer to recover. One interpretation for these findings is that children with migraine may experience an exaggerated duration of sympathetic activation after stress due to a disinhibition of the parasympathetic nervous system, which is designed to aid in the body's recovery to homeostasis after a stressor. Given that children suffering from migraine in the study also reported more anxiety compared to their peers, their inability to regulate their emotions adaptively may play a role in these children's rigid stress response. Thayer and Lane (2000) propose a theory of neurovisceral integration in emotion regulation that states that a positive feedback loop from the Central Autonomic Network (CAN) to the heart occurs when parasympathetic activation is disinhibited, leading to a sympathetically driven autonomic nervous system that is unable to inhibit attention from maladaptive information or coping strategies (e.g. rumination or worry), fails to regulate emotions, and produces hyperarousal. It is possible that children with migraine exhibit this same pattern, thereby explaining their proclivity towards both anxiety and difficulty recovering from a stressor.

Clinical Implications

If children with migraine do exhibit autonomic dysregulation in the form of parasympathetic disinhibition and emotional dysregulation, several existing treatments may be beneficial. Cognitive behavioral therapy (CBT) to address ruminative patterns and maladaptive thinking patterns that perpetuate anxiety may decrease worry, thereby increasing heart rate variability. Researchers are already investigating CBT's effect on heart rate variability in anxious adults with promising results (Friedman, Thayer, & Borkovec, 1993). Acceptance based therapies, including Mindfulness Based Cognitive Therapy, may also be helpful for these children. The goals of this approach are to increase individuals' awareness and acceptance of their physical arousal, anxiety, pain,

and maladaptive thought patterns in the moment without trying to change them (Baer & Huss, in press). These approaches also have a goal of helping the individual to decenter from the experience in order to take an objective perspective of the sensations and not become caught up in the moment of the experience, which often occurs with rumination.

In addition, Physical Self-regulation Training (PSR; Carlson, Bertrand, Ehrlich, Maxwell, & Burton, 2001) may further aid in the increase in parasympathetic activation and resulting decrease in sympathetic activity in children with migraine. Treatments that focus on physical self-regulation techniques would likely be beneficial in reducing prolonged sympathetic activation as they teach relaxation strategies that increase parasympathetic activation, thereby decreasing sympathetic activity. PSR is a manual-based treatment that involves teaching diaphragmatic breathing, stretching exercises, and postural changes. While this treatment has been used primarily to address chronic pain associated with individuals suffering from orofacial pain and studies have not investigated its effect on heart rate variability or with children with migraine, the basic components of the protocol aim to increase the body's ability to self-regulate, which intuitively would influence heart rate variability and thereby lessen pediatric migraine frequency and intensity.

Limitations and Future Directions

Previous studies have investigated the physiological differences between children with migraine and their peers using physical tests such as the sustained hand grip test or the orthostotic test as well as mental tests such as mental subtraction. Moreover, previous studies have measured physiological differences by investigating differences in heart rate, skin temperature, and blood pressure. This study improves upon the literature by encouraging participants to discuss a personally relevant stressor in detail in an effort to evoke emotions similar to those experienced during the actual stressor as means to produce physiological results consistent with actual physiological changes that occur in real-life situations. In addition, this study also used heart rate variability as a measure of autonomic functioning since previous research indicates it is a sensitive measure of the complex sympathetic-parasympathetic function of the autonomic nervous system. Despite these additions to the literature, this study does have limitations. Future studies utilizing larger sample sizes with children who have not begun pharmacological

treatments for migraine would allow for a purer sample to investigate physiological differences that may exist between these patients and their peers. Future studies may also benefit from measuring respiration and including it in the analyses given that respiration rates influence heart rate variability; however, obtaining complete respiration data was very challenging in this study due to the need for participants to remain still and for the sensitive transducer to remain in place. Finally, future investigations could record and xplore the narratives of the participants to shed more light into the quality of their descriptions, including the coping or ruminative patterns that may be occurring, as well as their behavioral responses during the stressor.

In summary, children suffering from migraine compared to their peers, exhibit higher resting heart rates and require a longer recovery period after an emotional stressor. They also report more anxiety symptoms. These results suggest a disinhibition of the parasympathetic nervous system which leads to a prolonged sympathetic activation. This is consistent with the current theory of the pathophysiology of migraine, the spreading activation theory. Children with migraine likely experience an underlying faulty stress response system that may trigger the neurochemical reactions needed to initiate a migraine attack. Research investigating the relation between sleep difficulties and migraine are limited and inconclusive. This study failed to find a significant relation between sleep difficulties and the presence of migraines, but did find significant positive relations between sleep difficulties and migraine characteristics. Additional research is needed to clarify whether a relation actually exists and if so, the form of this relation. The present results suggest that sleep difficulties, migraine attacks, and anxiety may be a result of a general dysfunctional autonomic nervous system.

Appendix 1

Demographic Questionnaire

Research Number:_____

Date:_____

Age:_____

Gender:_____

Grade:_____

Height:_____ (To be completed by researcher)

Weight:_____ (To be completed by researcher)

Child's race/ethnicity:_____

Do Both parents live at home: (If no, please indicate who lives with child)_____

Mom's Highest Education Level:_____

Appendix 2

Children's Medical Questionnaire

DEPARTMENT OF NEUROLOGY
UNIVERSITY OF KENTUCKY
KENTUCKY CLINIC

CHILD NEUROLOGY
CHILD'S MEDICAL HISTORY

DATE: _____

		YES	NO
1.	**In the past six months has your child had bad headaches?**		
	If YES please answer EACH of the following questions:	☐	☐

Did the headache make your child:	YES	NO
Sick to the stomach?	☐	☐
Affect vision or eyesight?	☐	☐
Hurt on only one side of the head at a time?	☐	☐
Radiate to or from the back and shoulders?	☐	☐
Other (describe):	☐	☐

		YES	NO
2.	**In the past six months has your child had eye trouble?**		
	If YES please answer EACH of the following questions:	☐	☐

	YES	NO
Blurring or loss of vision lasting more than a minute or two?	☐	☐
Pain in the eye?	☐	☐
Spells of seeing double?	☐	☐
Other (describe):	☐	☐

		YES	NO
3.	**In the past six months has your child had ear, nose or mouth problems?**		
	If YES please answer EACH of the following questions:	☐	☐

	YES	NO
Ear infections?	☐	☐
Drainage from the ear(s)?	☐	☐
Loss of hearing?	☐	☐
Nosebleeds not caused by injury or a cold?	☐	☐
A stuffy or runny nose almost every day?	☐	☐
Bleeding gums or a burning or sore mouth?	☐	☐
Other (describe)	☐	☐

4. **In the past six months has your child had throat problems** YES ☐ NO ☐

If YES please answer EACH of the following questions:

	YES	NO
A hoarse voice that has not improved?	☐	☐
Difficulty swallowing solid foods or liquids	☐	☐
Frequent sore throats or strep throats?	☐	☐
Other (describe)	☐	☐

5. **In the past six months has your child had breathing or chest problems?** YES ☐ NO ☐

If YES please answer EACH of the following questions:

	YES	NO
Shortness of breath at rest or during sleep?	☐	☐
Wheezing?	☐	☐
Pneumonia?	☐	☐
Chest pain with activity?	☐	☐
Other (describe)	☐	☐

6. **In the past six months has your child had digestive problems?** YES ☐ NO ☐

If YES please answer EACH of the following questions:

	YES	NO
Stomach pain?	☐	☐
Loss of bowel training?	☐	☐
Black, tarry or bloody stools?	☐	☐
Other (describe)	☐	☐

7. **In the past six months has your child had bladder problems?** YES ☐ NO ☐

If YES please answer EACH of the following questions:

	YES	NO
Has your child been toilet trained and has now resumed wetting?	☐	☐
Burning or pain with urination?	☐	☐
Blood in the urine?	☐	☐
Other (describe)	☐	☐

8. **In the past six months has your child had a problem with joints or back?** YES ☐ NO ☐

If YES please answer EACH of the following questions:

	YES	NO
A back or joint injury or pain?	☐	☐
Hot, red or swollen joints?	☐	☐
Other	☐	☐

9. **In the past six months has your child had behavioral problems (that were age inappropriate)?** YES ☐ NO ☐

If YES please answer EACH of the following questions:

	YES	NO
Too much activity or too short an attention span?	☐	☐
Aggressive (hitting, bitting, pinching)?	☐	☐
Does not interact appropriately with adults or other children?	☐	☐
Does not play with toys in the normal way?	☐	☐
Other (describe)	☐	☐

Has your child's development been normal? YES ☐ NO ☐

If NO please explain: _____

_____

In the past six months has your child been on any prescription or non-prescription medicine? YES ☐ NO ☐

If Yes list Medicines:	STRENGTH	DAILY DOSE	TAKING IT NOW?	COMMENT

Does your child smoke cigarettes? YES ☐ NO ☐

Does your child drink alcoholic beverages or use drugs? YES ☐ NO ☐

Does your child have drug allergies (reactions)? YES ☐ NO ☐

If YES list all drugs and type of reaction:

DRUG	REACTION	COMMENT

PAST MEDICAL HISTORY

Below is a list of health problems. Please check YES for those that your child has experienced.

	YES		YES		YES
ADHD (Hyperactivity)	☐	Heart Problems	☐	Overweight	☐
Asthma	☐	High Blood Pressure	☐	Rheumatic Fever	☐
Behavior Problems	☐	Jaundice/Liver Disease	☐	Seizures	☐
Birth Defect	☐	Kidney Disease	☐	Stroke	☐
Cancer	☐	Learning Problems	☐	Severe Trauma or Head Injury	☐
Cerebral Palsy	☐	Liver Disease or Jaundice	☐	Thyroid Disease	☐
Diabetes	☐	Loss of Consciousness	☐		☐

List any surgeries or other major illnesses your child has experienced:

_____

_____

_____

Birth History: Birth Weight:_____ Gestational age:_____

Complications of Pregnancy:_____

Complications of Birth:_____

FAMILY HISTORY

Common health problems are listed below. If one or more of the child's blood-related family members has experienced that problem please write in the appropriate number.

Use these numbers: Mother - 1 Father - 2 Sister - 3 Brother - 4
Maternal Grandparent - 5 Paternal Grandparent - 5 Other relative - 9

Example: Epilepsy - child's mother and 2 sisters have this problem. Answer: 1, 3, 3

ADHD (hyperactivity).....	Glaucoma.....	Movement Disorder (like chorea).....
Allergy.....	Heart Disease.....	Neurofibromatosis.....
Asthma.....	High Blood Pressure.....	Seizures or Epilepsy.....
Birth Defect.....	Learning Disorder.....	Stroke.....
Brain Tumor.....	Mental or Behavior Disorder.....	Tics or Tourettes.....
Cancer (not brain tumor).....	Mental Retardation.....	Tuberous Sclerosis.....
Diabetes.....	Migraine.....	

List any of the child's brothers or sisters who have died and any (blood related) family members who died in childhood.

FAMILY MEMBER	AGE	CAUSE	FAMILY MEMBER	AGE	CAUSE

Child's Parents: Married..... ☐ Separated.... ☐ Single..... ☐ Divorced..... ☐ Widowed..... ☐

Number of children_____ Ages of children_____

Adults in the home_____ Relationship of adults_____

_____

Occupations: Mother_____ Father_____

Last grade of school completed or degree obtained: Child_____

Mother_____

Father_____

Signature of Reviewing M.D._____ Date:_____

References

Abidin, RR. (1995). Parenting Stress Index 3rd Edition: Professional Manual. Psychological Assessment Resources, Inc.: Odessa, FL.

Abu-Arefeh, L. & Russell, G. (1994). Prevalence of headache and migraine in schoolchildren. *BMJ,* 309(24), 765-769.

Anttila, P., Metsahonkala, L., Helenius, H., & Sillanpaa, M. (2000). Predisposing and provoking factors in childhood headache. *Headache*, 40, 351-356.

Aromaa, M., Rautava, P., Helenius, H., & Sillanpaa, M. (1998). Factors of early life as predictors of headache in children at school entry. *Headache*, 38-23-30.

Aromaa, M., Sillanpaa, M., Rautava, P., & Helenius, H. (1998). Childhood headache at school entry: A controlled clinical study. *Neurology*, 50(6), 1729-1736.

Baer, R.A. & Huss, D.B**.** (in press), The Use of Mindfulness/Acceptance approaches in psychotherapy. Invited book chapter in *21st Century Psychotherapies* by John Wiley & Sons.

Baharav, A., Kotagal, S., Gibbons, V., Rubin, B.K., Pratt, G., Karin, J., & Akselrod, S. (1995). Fluctuations in autonomic nervous activity during sleep displayed by power spectrum analysis of heart rate variability, *Neurology*, 45, 1183-1187.

Bar-Haim, Y., Fox, NA., VanMeenen, KM., & Marshall, PJ. (2004). Children's narratives and patterns of cardiac reactivity. *Developmental Psychobiology*, 44, 238-249.

Bates, J.E., Viken, R.J., Alexander, D.B., Beyers, J., & Stockton, L. (2002). Sleep and adjustment in preschool children: Sleep diary reports by mothers relate to behavior reports by teachers. *Child Development*, 73(1), 62-74.

Bieri, D., Reeve, RA., Champion, GD., Addicoat, LA., & Ziegler, JB. (1990). The faces pain scale for the self-assessment of the severity of pain experienced by children: Development, initial validation, and preliminary investigation for ratio scale properties. *Pain*, 41(2), 139-150.

Bille, B. (1997). A 40-year follow-up of school children with migraine. *Cephalalgia*, 17, 88-491.

Blau, JN. & Thavapalan, M. (1988). Preventing migraine: A Study of precipitating factors. *Headache*, 28, 481-483.

Bolay, Hayrunnisa, Reuter, Uwe, Dunn, Andrew K., Huang, Zhihong, Boas, David A., & Moskowitz, Michael A. (2002) Intrinsic brain activity triggers trigeminal meningeal afferents in a migraine model. *Nature Medicine*, 8(2), 136-142.

Breslau, N., & Davis, G. (1993). Migraine, physical health and psychiatric disorder: a prospective epidemiologic study in young adults. *Journal of PsychiatricResearch, 27*, 211-221.

Breslau, N., Davis, G., & Andreski, P. (1991). Migraine, psychiatric disorders, and suicide attempts: an epidemiologic study of young adults. *Psychiatry Research, 37*, 11-23.

Bruni, O., Fabrizi, P., Ottaviano, O., Cortesi, F., Giannotti, F., & Guidetti, V. (1997). Prevalence of sleep disorders in childhood and adolescents with headache: A case control study. *Cephalalgia*, 17, 492-498.

Bruni, O. Galli, F., & Guidetti, V. (1999). Sleep hygiene and migraine in children and adolescents. *Cephalalgia*, 19 (supplement 25), s1-s9.

Bruni, O., Russo, P.M., Violani, C., & Guidetti, V. (2004). Sleep and migraine: An actigraph study. *Cephalalgia*, 24, 134-139.

Carlson, C.R., Betrand, P.M., Ehrlich, A.D., Maxwell, A.W., & Burton, R.G. (2001). Physical self-regulation training for the management of temporomandibular disorders. *Journal of Orofacial Pain,* 15, 42-55.

Carskadon, M. (1990). Patterns of sleep and sleepiness in adolescents. *Pediatrician, 17*, 5-12.

Chen, E., Matthews, K., Salomon, K., & Ewart, C. (2002). Cardiovascular reactivity during social and nonsocial stressors: Do children's personal goals and expressive skills matter? *Health Psychology*, 21(1), 16-24.

Dearing, E., McCartney, K., Marshall, N., & Warner, R. (2001). Parental reports of children's sleep and wakefulness: Longitudinal associations with cognitive and language outcomes. *Infant Behavior and Development, 24*, 151-170.

Ewart, Ck. & Kolodner, KB. (1991). Social Competence Interview for Assessing Physiological Reactivity in Adolescents. *Psychosomatic Medicine*, 53, 289-304.

Fallone, G., Acebo, C., Arnedt, T., Seifer, R., & Carskadon, M. (2001). Effects of acute sleep restriction on behavior, sustained attention, and response inhibition in

children. *Perceptual and Motor Skills*, 93, 213-229.

Ferri, R., Curzi-ascalova, L., Arzimanoglou, A., Bourgeois, M., Beaud, C., Nunes, ML. et al. (2002) Heart rate variability during sleep in children with partial epilepsy. *Journal of Sleep Research*, 11, 153-160.

Finley, JP. & Nugent, ST. (1995). Heart rate variability in infants, children, and young adults. *Journal of the Autonomic Nervous System*, 103-108.

Fisher, B., & Rinehart, S. (1990). Stress, arousal, psychopathology and temperament: A multidimensional approach to sleep disturbances in children. *Personality and Individual Differences, 11*, 431-438.

Friedman, B.H., Thayer, J.F., & Borkvec, T.D. (1993). Heart rate variability in generalized anxiety disorder. *Psychophysiology,* 30, S28.

Gottlieb, D., Vezina, R., Chase, C., Lesko, S., Heeren, T., Weese-Meyer, D., Auerbach, S., & Corwin, M. (2003). Symptoms of sleep-disordered breathing in 5 year-old children are associated with sleepiness and problem behaviors. *Pediatrics, 112*(4), 870-877.

Guidetti, V., Galli, F., Fabrizi, P., Giannantoni, A.S., Napoli, L., Bruni, O., & Trillo, S. (1998). Headache and psychiatric comorbidity: Clinical aspects and outcome in an 8- year follow-up study. *Cephalalgia*, 18, 455-462.

Hall, M., Vasko, R., Buysse, D., Ombao, H., Chen, Q., Cashmere, JD., Kupfer, D., & Thayer, JF. (2004). Acute stress affects heart rate variability during sleep. Psychosomatic medicine, 66(1), 55-62.

Hamel, E. (1999). The Biology of Serotonin Receptors: Focus on Migraine Pathophysiology and Treatment. *Canadian Journal of Neurological Sciences*, 26 (3), s2-s6.

Hansen, DE. & Vandenburg, R. (2001). Cognitive effects of sleep apnea and narcolepsy in school-aged children. *Sleep and Hypnosis*, 3(2), 73-80.

Heragu, NP. & Scott, WA. (1999). Heart rate variability in healthy children and in those with congenital heart disease both before and after operation. *American Journal of Cardiology*, 83, 1654-1657.

Herman, C. & Blanchard, EB. (1998). Psychophysiological reactivity in pediatric migraine patients and healthy controls. *Journal of Psychosomatic Research*, 44(2), 229-240.

Hershey, AD., Powers, SW., Vockell, A-LB., LeCates, S., Kabbouhce, MA., & Maynard, MK. (2001). PedMIDAS: Development of a questionnaire to assess disability of migraines in children. *Neurology*, 2034-2039.

Hicks, CL., von Baeyer, CL., Spafford, PA., van Korlaar, I., & Goodenough, B. (2001). The Faces pain scale- revised: Toward a common metric in pediatric pain measurement. *Pain*, 93, 173-183.

Holmes, W.F., MacGregor, E.A., Dodick, D. (2001). Migraine- related disability: Impact and implications for sufferers' lives and clinical issues. *Neurology*, 56, S13-S19.

Hunfeld, J., Passchier, J., Perquin, C. W., Hazebroek-Kampschreur, A., van Suijlekom-Smit, L., & van der Wouden, J. (2001). Quality of life in adolescents with chronic pain in the head or at other locations. *Cephalalgia, 21*, 201-206.

Kaemingk, KL, Pasvogel, AE, Goodwin, JL, Mulvaney, SA, Martinez, F., Enright, PL, Rosen, GM, Morgan, WJ, Fregosi, RF, & Quan SF. (2003). Learning in children and sleep disordered breathing: Findings of the Tuscan children's assessment of Sleep Apnea (TuCASA) prospective cohort study *Journal of International Neuropsychological Society*, 9(7), 1016-1026.

Kazuma, N., Ostuka, K., Wakamatsu, K., Shirase, E., & Matsuoka, I. (2002). Heart rate variability in normotensive healthy children with aging. *Clinical and Experimental Hypertension,* 24(1&2), 83-89.

King, N., Ollendick, T. H., & Tongue, B. J. (1997). Children's nighttime fears. *Clinical Psychology Review, 117*, 431-443.

Kowal, A. & Pritchard, D. (1990). Psychological characteristics of children who suffer from headache: A research note. *Journal of Child Psychology and Psychiatry*, 31(4), 637-649.

Lathi, BP. (1992). *Linear Systems and Signals.* Carmichael, CA: Berkeley-Cambridge Press.

Lee, L. H., & Olness, K. N. (1997). Clinical and demographic characteristics of

migraine in urban children. *Headache, 37*, 269-276.

MacKinnon, D.P., Lockwood, C.M., Hoffman, J.M., West, S.G., & Sheets, V. (2002). A comparison of methods to test mediation and other intervening variables. *Psychological Methods, 7,* 83-104.

Mandigout, S., Melin, A., Fauchier, LD., N'Guyen, D., Courteix, D., & Obert, P. (2002). Physical training increases heart rate variability in healthy prepubertal children. *European Journal of Clinical Investigation,* 32, 479-487.

March, J. (1997). The Multidimensional Anxiety Scale for Children (MASC). Multi-Health Systems Inc., North Tonoawanda, NY.

Massin, M. & von Bernuth, G. (1997). Normal ranges of heart rate variability during infancy and childhood. *Pediatric Cardiology*, 18, 297-302.

Miller, V.A., Palermo, T.M., Powers, S.W., Scher, M.S., & Hersehy, A.D. (2003). Migraine headaches and sleep disturbance in children. *Headache*, 43, 362-368.

Mindell, J. A. (1993). Sleep disorders in children. *Health Psychology, 12*, 151- 162.

Mindell, J. A., & Owens, J. A. (2003). *A Clinical guide to pediatric sleep: Diagnosis and management of sleep problems.* Philadelphia: Lippincott Williams and Wilkins.

Mitru, G., Millrood, D. L., & Mateika, J. H. (2002). The impact of sleep on learning and behavior in adolescents. *Teachers College Record, 104*(4), 704-726.

Monk, C., Kovelenko, P., Ellman, LM., Sloan, RP., Bagiella, Gorman, JM., et al. (2001). Enhanced stress reactivity in paediatric anxiety disorders: implications for future cardiovascular health. *International Journal of Neuropsychopharmacology*, 4, 199-206.

Moore, M. (1989). Disturbed attachment in children: A function of sleep disturbance, altered dream production and immune dysfunction. Not safe to sleep: Chronic sleep disturbances in anxious attachment. *Journal of Child Psychotherapy, 15*, 99-111.

Mortimer, J., Kay, J., & Jaron, A. (1992). Epidemiology of headache and childhood migraine in an urban general practice using Ad Hoc, Vahlquist and IHS criteria. *Dev Med Child Neurol, 34*, 1095-1101.

Moskowitz, MA. (1993). Neurogenic inflammation in the pathophysiology and

treatment of migraine. *Neurology*, 43, S16-S20.

Muris, P., Merckelbach, H., Gadet, B., & Moulaert, V. (2000). Fears, worries, and scary dreams in 4 to 12 year-old children: their content, developmental patterns, and origins. *Journal of Clinical Child Psychology, 29*, 43-52.

Neveus, T., Crattingius, S., Olsson, U., & Hetta, J. (2001). Sleep habits and sleep problems among a community sample of schoolchildren. *Acta Paediatr*, 90, 1450-1455.

Osterhaus, SOL. & Passchier, J. (1992). Perception of triggers in young, nonclinical school students with migrainous headaches and tension headaches. *Perceptual Motor Skills*, 75, 284-286.

Owens, J., Maxim, R., McGuinn, M., Nobile, C., Msall, M., & Alario, A. (1999). Television viewing habits and sleep disturbance in school children. *Pediatrics, 104*, e27.

Owens, J.A., Spirito, A.,& McGuinn, M.(2000). The children's sleep habits questionnaire (CSHQ): psychometric properties of a survey instrument for school-aged children. *Sleep*, 23, 1043-1051.

Owens, J. A., Spirito, A., McGuinn, M., & Nobile, C. (2000). Sleep habits and sleep disturbance in elementary school-aged children. *Developmental and Behavioral Pediatrics, 21*(1), 27-34.

Paavonen, E., Solantaus, T., Almqvist, F., & Aronen, E. T. (2003). Four-year follow-up study of sleep and psychiatric symptoms in preadolescents: Relationship of persistent and temporary sleep problems to psychiatric symptoms. *Developmental and Behavioral Pediatrics, 24*(5), 307-314.

Passchier, J. & Orlebeke, JF. (1985). Headaches and stress in school children: An Epidemiological study. *Cephalalgia*, 5, 167-176.

Peroutka, SJ. (2004). Migraine: A Chronic sympathetic nervous system disorder. *Headache*, 44, 53-64.

Pivik, RT., Busby, KA., Gill, E., Hunter, P., & Nevins, R., (1996). Heart, autonomic nervous system and sleep: Heart rate variations during sleep in preadolescents, *Sleep*, 19(2), 117-135.

Powers, SW., Patton, SR., Hommel, KA., & Hershey, AD. (2004). Quality of life

in paediatric migraine: Characterization of age-related effects using PedsQL 4.0 *Cephalalgia*, 24, 120-127.

Powers, SW., Patton, SR., Hommel, KA., & Hershey, AD. (2003). Quality of life in childhood migraines: Clinical impact and comparison to other chronic illnesses. *Pediatrics*, 112(1), e1-e5.

Randazzo, A., Muehlbach, M., Schweitzer, P., & Walsh, J. (1998). Cognitive functioning following acute sleep restriction in children ages 10-14. *Sleep*, 21(8), 861- 868.

Rhodes, RD., Harrison, DW., & Demaree, HA. (2002). Hostility as a moderator of physiological reactivity and recovery to stress. *International Journal of Neuroscience*, 112, 167-186.

Riihimaa, PH., Suominen, K., Knip, M., Tapanainen, P., & Tolonen, U. (2002). Cardiovascular autonomic reactivity is decreased in adolescents with Type 1 diabetes. *Diabetes Medicine,* 19, 932-938.

Sadeh, A. (1996). Stress, trauma, and sleep in children. *Child and Adolescent Psychiatric Clinics of North America, 5*, 685-700.

Sadeh, A., Gruber, R., & Raviv, A. (2002). Sleep, neurobehavioral functioning, and behavior problems in school-age children. *Child Development, 73*(2), 405-417.

Sadeh, A. & Raviv, A. (2003). The effects of sleep restriction and extension on school-age children: What a difference an hour makes. *Child Development*, 74 (2), 444-455.

Sadeh, A., Raviv, A., & Gruber, R. (2000). Sleep patterns and sleep disruptions in school-age children. *Developmental Psychology, 36*(3), 291-301.

Sancehz del Rio, M, Reuter, U., & Moskowitz, MA. (2000). Central and peripheral mechanisms of migraine. *Functional Neurology*, 15(3), 157-162.

Scheeringa, MA., Zeanah, CH., Myers, L., & Putnam, F. (2004). Heart period and variability findings in preschool children with posttraumatic stress symptoms. *Biological Psychiatry,* 55, 685-691.

Seshia, SS., Wolstein, JR., Adams, C., Booth, FA., & Reggin, JD. (1995). International Headache Society classification and diagnostic criteria in children: a proposal for revision. *Developmental Medicine & Child Neurology*, 37, 879-882.

Sillanpaa, M. (1976). Prevalence of migraine and other headache in Finnish children starting school. *Headache, 15*, 288-290.

Sillanpaa, M. (1994). Headache in children. In J. Olesen (Ed.), *Headache Classification and Epidemiology.* (pp. 273-281). New York: Raven Press.

Silvetti, MS., Drago, F., & Ragonese, P. (2001). Heart rate variability in healthy children and adolescents is partially related to age and gender. *International Journal of Cardiology*, 81, 169-174.

Srinivasan, K., Ashok, M.V., Vaz, Mario, & Yeragani, V.K. (2002). Decreased chaos of heart rate time series in children of patients with panic disorder. *Depression and Anxiety,*15, 159-167.

Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology. (1996). Heart Rate Variability: Standards of Measurement, Physiological Interpretation, and Clinical Use. *Circulation*, 1043-1065.

Thayer, J.F., Friedman, B.H., & Borkovec, T.D. Autonomic characteristics of generalized anxiety disorder and worry. *Biological Psychiatry,* 39, 255-266.

Thayer, J.F. & Lane, R.D. (2000). A model of neurovisceral integration in emotion regulation and dyregulation. *Journal of Affective Disorders,* 61, 201-216.

Vaughn, B.V., Quint, S.R., Messenheimer, J.A., & Robertson, KR. (1995). Heart period variability in sleep. *Electroencephalogr. Clinical Neurophysiology*, 94, 155-162.

Villa, MP., Calcagnini, G., Pagani, J., Paggi, B., Massa, F., & Ronchetti, R. (2000). Effects of sleep stage and age on short-term heart rate variability during sleep in healthy infants and children. *Chest*, 117(2), 460-466.

Waeber, C. & Moskowitz, MA. (2003). Therapeutic implications of central and peripheral neurologic mechanisms in migraine. *Neurology*, 61, S9-S20.

Waldie, KE. (2001). Childhood headache, stress in adolescence, and primary headache in young adulthood: A Longitudinal cohort study. *Headache*, 41, 1-10.

Winner, P., Wasiewski, W., Gladstein, J., & Linder, S. (1997). Multi-center prospective evaluation of proposed pediatric migraine revisions to the IHS criteria. Pediatric Headache Committee of the American Association for the Study of Headache. *Headache, 37*, 545-548.

Winsley, RJ., Armstrong, N., Bywater, K., & Fawkner, SG. (2003). Reliability of heart rate variability measures at rest and during light exercise in children. *British Journal of Sports Medicine,* 37, 550-552.

Wolfson, A. (1996). Sleeping patterns of children and adolescents: Developmental trends, disruptions, and adaptations. *Child and Adolescent Psychiatric Clinics of North America, 5*, 549-568.

Wolfson, A.R., & Carskadon, M.A. (1998). Sleep schedules and daytime functioning in adolescents. *Child Development*, 69(4), 875-887.

Yakinci, C., Mungen, B., Er., H., Durmaz, Y., & Karabiber, H. (1999). Autonomic nervous system function in childhood migraine. *Pediatrics International*, 41, 529-533.

Yeragani, VK., Rao, KA., Pohl, R., Jampala, VC., & Balon, R. (2001). Heart rate and QT in children with anxiety disorders: A preliminary report. *Anxiety and Depression*, 13(2), 72-77.

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PUBLICATIONS

Baer, R.A., Fishcer, S., & **Huss, D.B.** (2005). Mindfulness-based cognitive therapy applied to binge eating disorder: A case study. *Cognitive and Behavioral Practice, 12,* 351-358.

MANUSCRIPTS IN PRESS

Baer, R.A., Fischer, S. & **Huss, D.B**. Mindfulness and acceptance in the treatment of disordered eating. For special issue on mindfulness and self-acceptance, *Journal of Rational Emotive and Cognitive Behavioral Therapy*.

Huss, D.B. & Baer, R.A. Acceptance and change: Integration of mindfulness-based cognitive therapy into ongoing dialectical behavior therapy in a case of borderline personality disorder with depression. *Clinical Case Studies*.

Baer, R.A. & **Huss, D.B.** The Use of Mindfulness/Acceptance approaches in psychotherapy. Invited book chapter in *21st Century Psychotherapies* by John Wiley & Sons.

POSTER PRESENTATIONS

Huss, D.B., Schmidt, J.Balasubramanium, R., Okeson, J., & Carlson, C.R. (2004,

November). Predictors of fatigue in orofacial pain patients. Poster presented at the annual meeting of the Association for the Advancement of Behavior Therapy, New Orleans, LA.

Huss, D.B., Fischer, S., & Baer, R. (2003, November) *Mindfulness based cognitive therapy applied to binge eating: A case study*. Poster presented at the annual meeting of the Association for the Advancement of Behavior Therapy, Boston, MA.

Huss, D.B., Andrykowski, M.A., Beacham, A., & Jacobsen, P. (2003, March). The effects of personality traits and breast cancer treatment on physical and mental health outcomes. Poster presented at the annual meeting of the Society of Behavioral Medicine, Salt Lake City, Utah.

Debra B. Huss
November 19, 2007