AN ABSTRACT OF THE THESIS OF

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Sleep is an active process that affects an individual's daily functioning and physical and mental health. It is also beneficial for an individual's overall health and well being. Children with autism often have difficulty sleeping. One common complaint from parents of children with autism is that these children lack sufficient sleep. The purpose of this study was to examine the effects of physical activity on sleep in children with autism. There were three specific research questions for this study. The first question was to examine the amount of physical activity during the day to determine if physical activity had a beneficial effect on sleep. The second question was to examine the effect of physical activity within 1 hour of bedtime on sleep. The third question was to examine the effect of physical activity within 2-3 hours of bedtime on sleep.

Twelve children between the ages of 3 and 11 years with autism who have a sleep problem participated in this study. Children's physical activity and sleep were assessed with an Actiwatch® for 14 consecutive days. During this time, all children maintained their normal daily routine and parents completed a sleep log. The sleep

logs were used to determine what time the children went to bed and what time the children woke up. The effect of physical activity on sleep was examined by comparing the 5 most active days vs. the 5 least active days within a child's 14 days of data collection.

A one-way repeated MANOVA showed that there was a significant effect, Wilk's ? = .32, ($p < .05$) of low level physical activity on sleep efficiency when performed within 1 hour of bedtime. The findings suggested that higher levels of physical activity prior to sleep have a negative effect on sleep efficiency. This finding is similar to previous reports stating that physical activity prior to bedtime can be disruptive for sleep. There were no other effects of physical activity on sleep in children with autism determined in this study.

These results did not provide support for the effect of physical activity on sleep in children with autism. Since this study only tested 12 children with autism, future research should be conducted with a larger sample size. It is also suggested that future research use a physical activity intervention and more consecutive days of data collection.

The Effect of Physical Activity on Sleep in Children with Autism

by

Kristine Ann Hagar

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Kristine Ann Hagar, Author

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CONTRIBUTION OF AUTHORS

Dr. Joonkoo Yun was involved in the data analysis and writing of the manuscript.

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DEDICATION

This thesis is dedicated to my mother

Lucinda M. Hagar

for giving me the strength to pursue my dreams.

THE EFFECT OF PHYSICAL ACTIVITY ON SLEEP IN CHILDREN WITH AUTISM

CHAPTER 1: INTRODUCTION

BACKGROUND

Sleep problems in children with autism have been well documented in the literature (Hering, Epstein, Elroy, Iancu, & Zeinik, 1999; Hoshino, Watanabe, Yashima, Kaneko, & Kumashiro, 1984; Johnson, 1996; Richdale, 1999; Richdale & Prior, 1995; Patzold, Richdale, & Tonge, 1998; Schreck & Mulick, 2000; Thirumalai, Shubin, & Robinson, 2002; Weiskop, Matthews, & Richdale, 2001). Children with autism have been found to suffer from sleep problems more than any other group of children with disabilities (Richdale & Prior, 1995). According to Richdale (1999) sleep problems in children with autism are more severe and occur at a higher frequency than in children with other types of disabilities. Research has shown that between approximately 44.4 and 83.3% of children with autism have sleep problems (Richdale & Prior, 1995). In a sample of 75 children with autism, 65% had some form of sleep disturbance with a higher rate of sleep disturbance occurring in children with autism who were cognitively less developed (Hoshino et al., 1984).

Sleep problems in children with autism are usually very severe and consist of frequent problems with settling, falling asleep, maintaining sleep throughout the night, long periods of waking during the night, an earlier morning wake time, irregular sleep-wake patterns, bed wetting, and a shortened night of complete sleep (Johnson, 1996; Richdale, 1999; Patzold et al., 1998; Thirumalai et al., 2002; Weiskop et al., 2001).

Although, sleep problems in typically developing children tend to decrease or disappear altogether as the child gets older, sleep problems in children with autism can continue throughout adolescence (Sweeney, Hoffman, Ashwal, Stolz, 2003).

Sleep problems in children with autism have been found to negatively affect the child's daytime behavior and can interfere with the effectiveness of educational and behavioral programs (Honomichl, Goodlin-Jones, Burnham, Gayler, & Anders, 2002; Hoshino et al., 1984; Johnson, 1996; Richdale, 1999; Patzold et al., 1998; Thirumalai et al., 2002; Weiskop et al., 2001). Richdale (1999) states there are associations between problematic behaviors, energetic daytime behaviors, and sleep problems. Additionally, sleep problems add more stress onto an already stressed family life. A child's sleep problem will disrupt the entire family's sleep, causing added stress and also an increase in irritability (Honomichl, et al., 2002). Families will also experience a lack of sleep, which can then reduce their ability to deal with the challenging behaviors that are associated with autism (Sweeney, et al., 2003). The impact sleep problems in children with autism have on the child and the family makes it essential to find a form of intervention that will aid in decreasing sleep problems in children with autism.

Currently, two methods of intervention exist to help eliminate sleep problems in children with autism – traditional behavioral intervention and pharmacological treatment (Johnson, 1996; Weiskop et al., 2001). Traditional behavioral intervention comes from an applied behavior analysis approach and consists of using a consistent bedtime, extinction of the negative behaviors, and reinforcement of the positive behaviors (Johnson, 1996). Parents of children with sleep problems must be trained in

how to appropriately use these methods of intervention; therefore it can become expensive for the family. This approach also requires consistency, which can be difficult for some families. Pharmacological treatment consists of giving the child certain prescribed medications. Examples of these medications are benadryl and other antihistamines with sedative effects (Johnson, 1996). The literature does not recommend the use of medication for the treatment of sleep problems in children with autism because medication is an expensive form of treatment (Johnson, 1996). In addition, most children with autism are already on a number of different medications which can be detrimental to a child's health because of tolerance, negative side effects, and mortality (Youngstedt, Kripke, & Elliott, 1999). Due to the lack of support for these two forms of intervention, there is a critical need to develop a new, effective, and safe intervention to decrease sleep problems in children with autism. Physical activity is a possible solution to decreasing sleep problems in children with autism.

Physical activity has many different health-related and psychological benefits for people of all ages. (Amisola & Jacobson, 2003; Gabler-Halle et al., 1993; Healthy People 2010; Klepper, 2003; Macera et al., 2003; Shephard, 1995; Sothern et al., 1999;). The health-related benefits of physical activity are a) decreased risk of death from heart disease, b) lower risk of diabetes, c) decreased risk of colon cancer, d) prevention of high blood pressure, e) increased muscle and bone strength, f) increased lean muscle, g) decrease of body fat, and h) weight control (Amisola & Jacobson, 2003; Healthy People 2010; Klepper, 2003; Macera et al., 2003; Shephard, 1995; Sothern et al., 1999;). The documented psychological benefits of physical activity are a) reduced symptoms of depression, b) reduced symptoms of anxiety, c) improved

self-efficacy and confidence, d) reduced tension, e) reduced hostility, and f) improvement in overall mood and satisfaction in life (Gabler-Halle et al., 1993; Healthy People 2010; Klepper, 2003; Shephard, 1995; Sothern et al., 1999). According to Shephard (1995), there is "a growing recognition that physical activity and fitness influence many aspects of personal health" (p.288).

However, the benefit of physical activity on sleep is an area of controversy. A few studies have reported that acute physical activity has limited effects on sleep improvement in individuals without sleep problems (O'Connor & Youngstedt, 1995; Youngstedt et al., 1997; Youngstedt et al., 2003). These reported limited effects of physical activity on sleep may be due to the studies being completed with individuals who have no room for improvement in their sleep patterns. In fact, Youngstedt et al. (1997) pointed out a major limitation of many previous studies was that most of the published studies focused exclusively on good sleepers. Conversely, previous studies provide evidence that physical activity does have a positive effect on sleep in individuals who have sleep problems (Namazi et al., 1995; Tanaka et al., 2001). A meta-analysis completed by Youngstedt et al. (1997), which reviewed 38 studies with 211 effects on a total of 401 subjects, showed that acute exercise has a small to moderate effect on sleep. Conclusions on the effects of sleep based only on studies using individuals without sleep problems can be problematic because of the possible ceiling effects. Pharmacological treatment is no more effective than physical activity on sleep in individuals without sleep problems. However the benefits physical activity may have on sleep in individuals with sleep problems needs to be determined (Youngstedt, 2000).

According to Youngstedt (2000), physical activity may or may not affect sleep, depending on a number of factors. First, an individual's fitness level may either promote or be detrimental to sleep. The higher an individual's fitness level, the better the individual may sleep. Second, duration of the activity session can also affect sleep. If the session lasts longer than one hour, the length of sleep may be increased. Last, it is assumed that the proximity of the activity session to bedtime can actually decrease sleep. It is believed that if arousing activity is performed prior to going to bed, between 3 to 4 hours, sleep has the potential to be disrupted (Keenan, 1999). These factors and the effect that sleep has on exercise is a very complex matter and there really is no straightforward answer because exercise can be physiologically and psychologically beneficial for an individual, but at the same time stress the body (Montgomery & Dennis, 2004). Considering these factors and the controversy at hand, there remains to be limited evidence supporting the benefit of physical activity on a night of sleep.

RATIONALE

The rationale for this study is that children with autism have sleep problems that need to be decreased because of the negative effects on the individual and the family. Physical activity may be one possible solution to decreasing these sleep problems. Therefore, the purpose of this study was to examine the association between physical activity and sleep problems in children aged 3-11 years with autism.

Research Questions

The following research questions were investigated in this study:

1) Would the amount of physical activity during the day have a positive association with sleep efficiency, sleep latency, and actual sleep time in children with autism?
2) Would the amount of physical activity within one hour of bedtime have a positive association with sleep efficiency, sleep latency, and actual sleep time in children with autism?
3) Would the amount of physical activity within 2-3 hours of bedtime have a positive association with sleep efficiency, sleep latency, and actual sleep time in children with autism?

Assumptions

The following assumptions were made for this project:

1) Actiwatch® provided reliable and valid measurements of physical activity and sleep levels.
2) Wearing of the actigraph did not alter physical activity or sleep patterns.
3) Parents accurately completed the sleep log every night.

Limitations

1) Limited to 12 subjects with ages from 3 to 11 years.
2) The subjects were not randomly sampled.

3) Medication that may affect participants sleep pattern and physical activity was not controlled.
4) Traditional behavior management techniques were not controlled.
5) Limited to adverse effects from the previous day's activity.

CHAPTER 2

The Effect of Physical Activity on Sleep in Children with Autism

Kristine Ann Hagar

ABSTRACT

The purpose of this study was to determine the effectiveness of physical activity on decreasing sleep problems in 12 children with autism between the ages of 3 and 11 years. Physical activity and sleep were assessed with an Actiwatch® for 14 consecutive days. Children maintained their normal daily routine and parents completed a sleep log. A one-way repeated MANOVA showed a significant effect, ? = .32, ($p < .05$) of low level physical activity on sleep efficiency when performed within one hour of bedtime, suggesting higher levels of physical activity prior to sleep have a negative effect on sleep efficiency. Future research should be conducted using a larger sample, a physical activity intervention and more days of data collection.

INTRODUCTION

Sleep is an active process that affects an individual's daily functioning, as well as physical and mental health (Landis, 2002; National Institute of Neurological Disorders and Stroke [NINDS], n.d.). The five phases of sleep that an individual's body passes through at night are: stages 1, 2, 3, 4 or non-Rapid Eye Movement (NREM), and 5 or Rapid Eye Movement (REM) (Carno, Hoffman, Carcillo, & Sanders, 2003; Keenan, 1999; Landis, 2002; Lee, 1997; Shapiro, Griesel, Bartel, & Jooste, 1975; Youngstedt, 2000). The whole sleep cycle is better known as the NREM-REM cycle and results in unresponsiveness and disengagement from the environment, and body and limb paralyzation (Carno, et al., 2003; Keenan, 1999; Landis, 2002; Lee, 1997; Youngstedt, 2000). According to NINDS (n.d.), sleep is beneficial for an individual's overall health and well-being.

Children with autism often have difficulty sleeping (Hering, Epstein, Elroy, Iancu, & Zeinik, 1999; Johnson, 1996; Richdale, 1999; Schreck & Mulick, 2000; Thirumalai, Shubin, & Robinson, 2002). One common complaint from parents of children with autism is that their children lack sufficient sleep. Children with autism often have (a) difficulty falling asleep, (b) frequent awakenings throughout the night, (c) earlier morning wake up time, and (d) a shortened night of complete sleep (Johnson, 1996; Richdale, 1999; Patzold, Richdale, & Tonge, 1998; Thirumalai et al., 2002; Weiskop, Matthews, & Richdale, 2001). As a result of these problems sleeping, children with autism subsequently have more behavioral problems throughout the following day, engaging in more self-stimulatory and off-task behavior (Hoshino,

Watanabe, Yashima, Kaneko, & Kumashiro, 1984; Johnson, 1996; Richdale, 1999; Patzold et al., 1998; Thirumalai et al., 2002; Weiskop et al., 2001). Sleep problems in children with autism also disrupt the family's sleep, which causes more stress and irritability (Honomichl, Goodlin-Jones, Burnham, Gayler, & Anders, 2002). Due to the negative effect sleep problems have on children with autism and their families, an effective form of treatment is needed.

Two forms of treatment are being used to treat sleep problems in children with autism. These two forms of treatment are traditional behavioral intervention and pharmacological treatment (Johnson, 1996; Weiskop et al., 2001). Traditional behavioral intervention consists of using applied behavior analysis to extinguish negative behaviors and reinforce positive behaviors. Pharmacological treatment consists of giving children certain medications that have a sedative effect. These two forms of treatment may not be the best solutions to treating sleep problems in children with autism. Traditional behavioral intervention may not be a desirable solution to treating sleep problems in children with autism because it requires consistency, which can be difficult for some families to implement. Alternatively, the use of medication is not an ideal form of treatment because of expense, negative side effects, tolerance, and mortality (Johnson, 1996; Youngstedt, Kripke, & Elliott, 1999). Medications can have undesirable side effects on individuals. Also, tolerance can occur when using these medications for long periods of time. In addition, most children with autism are already on a lot of medication, which may make dosage and monitoring challenging. Due to the difficulty in implementing traditional behavioral intervention and the

negative side effects of medication, there is a critical need to find an alternative solution to decreasing sleep problems in children with autism.

Physical activity may be one possibility to decreasing sleep problems in children with autism. Engaging in physical activity has demonstrated many different physical and psychological benefits (Amisola & Jacobson, 2003; Gabler-Halle, Halle, & Chung 1993; USDHH, 2000; Klepper, 2003; Macera, Hootman, & Sniezek, 2003; Shepard, 1995; Sothern, Loftin, Suskind, Udall, & Blecker, 1999). Unlike the other two forms of treatment for sleep problems, physical activity is unobtrusive, inexpensive, has no known side effects, and enhances an individual's quality of life. However, there is limited research in the area of physical activity benefiting sleep. Previous studies have reported that physical activity has limited effects on sleep (O'Connor & Youngstedt, 1995; Youngstedt, O'Connor, & Dishman, 1997; Youngstedt, Perlis, O'Brien, Palmer, Smith, et al., 2003). Youngstedt (2000), however, pointed out that previous studies examining the effects of physical activity on sleep do not focus on individuals who have sleep problems, which may cause ceiling effects.

There are several factors that go into determining if physical activity has a beneficial effect on sleep. These factors are fitness, duration, and timing (Youngstedt, 2000). All of these factors can either promote or be detrimental to an individual's sleep. It is believed that the higher an individual's fitness level, the longer the activity session lasts, and the further away from bedtime the activity session occurs the better an individual may sleep (Youngstedt, 2000). Even with these factors, there still

remains disagreement as to whether physical activity promotes or is detrimental to sleep.

Due to the lack of current knowledge, further research is needed to determine the effect of physical activity on sleep in individuals with sleep problems. Therefore, the purpose of this study was to examine the effects of physical activity on sleep in children with autism who have sleep problems. There were three specific research questions for this study. The first question was to examine the association of physical activity during the day and sleep. The second question was to examine the association of physical activity within one hour of bedtime and sleep. The third question was to examine the association of physical activity within 2-3 hours of bedtime and sleep.

METHODS

Participants

Participants in this study were 13 children (11 boys and 2 girls) with autism between the ages of 3 and 11 years (M=6.08, SD=2.96 years) who have sleep problems. All participants were diagnosed with autism by a physician and/or school psychologist. Sleep problems of the participants were reported by the parents. Two of the 13 participants are taking melatonin for their sleep problems. Participants were recruited from local public schools, educational service district, and a community-based outreach exercise program for children with disabilities. Due to an incomplete sleep log, one of the participant's data was not included in the final analysis.

Subsequently, data was analyzed for the remaining 12 participants. The study was approved by the investigator's Institution Review Board. Written parental informed consent was obtained prior to all data collection.

Instrument

A Mini-Mitter (2000) Actiwatch®-16 was used to asses the children's sleep patterns as well as levels of physical activity. Actiwatch is an actigraph, which is a small device that is used to measure movement when attached to the wrist, waist, or ankle. (Ancoli-Israel, Cole, Alessi, Chambers, Moorcroft, & Pollak, 2003; de Souza, Benedito-Silva, Pires, Poyares, Tuflik, & Calil, 2003; Jean-Louis, Mendlowicz, von Gizycki, Zizi, & Nunes, 1999; Pollak, Tryon, Nagaraja, & Dzwonczyk, 2001; Sadeh, Hauri, Kripke, & Lavie, 1995; Sforza, Zamagni, Petiav, & Krieger, 1999). Actigraph has been used in a number of research studies to examine the effectiveness of sleep (e.g. Hague, Gilbert, Burgess, Ferguson, & Dawson, 2003; Tanaka, Taira, Arakawa, Toguti, Urasaki, et al., 2001; Youngstedt, et al., 1999; Youngstedt, et al, 2003) as well as levels of physical activity (e.g. Cooper, Page, Fox, & Misson, 2000; Puyau, Adolph, Vohra, & Butte, 2002; Sirard & Pate, 2001). Sleep is inferred by an absence of activity or movement because in general there is less limb movement during sleep than wakefulness (Hauri & Wisbey, 1992; Mullaney, Kripke, & Messin, 1980). The interval of data recording is known as an epoch, which is represented in either minutes or seconds. An epoch length is limited to a maximum of one minute (American Sleep Disorders Association, 1995). The epoch-by-epoch samples are stored in the actigraph for a predetermined amount of time and then downloaded into a computer program so

they can be displayed, scored, analyzed, and converted into sleep parameters (American Sleep Disorders Association, 1995).

This method of measurement can be more convenient than the use of the polysomnography (PSG), which is considered the most stringent criterion measure of assessing sleep (Paavonen, Fjallberg, Steenari, & Aronen, 2002; Lockley, Skene, & Arendt, 1999; Youngstedt, 2000). Although the PSG can provide detailed information about sleep physiology, this method is expensive and cumbersome when used to detect sleep or no sleep (Blood, Sack, Percy, & Pen, 1997). Jean-Louis, von Gizycki, Zizi, Spielman, Hauri, & Taub (1997) noted strong correlation between the PSG and the actigraph with the correlation ranging from .89 to .98. The actigraph is a good alternative to the PSG because actigraph is a) easy to use, b) objective, c) unobtrusive, d) cost effective, e) usable for long-term studies, and f) not as limited as the PSG in long-term studies of sleep (Dagan, Zeevi-Luria, Sever, Hallis, Yovel, et al., 1997; Pollak et al., 2001; & Jean-Louis et al., 1997). The actigraph recordings can be conducted over days or weeks under natural conditions, whereas the PSG must be conducted in a sleep lab (American Sleep Disorder Association, 1995).

Variables and Measures

The following variables were collected in order to assess the effects of physical activity on sleep: physical activity, sleep efficiency, sleep latency, and actual sleep time. Physical activity, which is an average count of movement, was measured by movement of the body and limbs. The variables sleep efficiency, sleep latency, and actual sleep time were used to measure sleep. Sleep efficiency is an index of the

amount of time the individual is in bed that is actually spent sleeping (Mini Mitter Company, Inc., 2000). Sleep latency is the period between the individual's bedtime and start of sleep (Mini Mitter Company, Inc.). Actual sleep time is the amount of time that is actually spent sleeping (Mini Mitter Company, Inc.). These variables were chosen because children with autism experience difficulty falling asleep and maintaining sleep throughout the night (Richdale, 1999; Johnson, 1996; Patzold et al., 1998; Thirumalai et al., 2002; Weiskop et al., 2001).

The variables were analyzed using the Actiware-Sleep Activity Monitoring Software (Mini Mitter Company, Inc., 2000). The Actiware-Sleep Software is a Windows based program that was created for the analysis of sleep. The Actiware-Sleep Software allows the user to analyze/score the data on a variety of different parameters and provides data management tools.

Procedures

Prior to data collection, the participants in the study wore either a wrist band or Actiwatch® for 3-5 days on their non-dominant wrist. This 3-5 day period allowed the participants to become accustomed to wearing something on their wrist. Data collection began after the familiarization period was over. All participants wore an Actiwatch® on their non-dominant wrist for 14 consecutive days. During data collection, parents completed a sleep log each day (see appendix E) and activity recording was collected every 30-seconds by Actiwatch®. The use of 30-second intervals has been used in previous sleep studies (e.g. Hague et al., 2003; Pollak et al. 2001). After approximately five days and ten days of data collection, the Actiwatch®

was replaced with a new Actiwatch®. This was done because the Actiwatch-16 was only able to store the maximum of 5 ½ days of data with 30 second interval recordings. These frequent contacts with the parents also facilitated accurate completion of the sleep log, which the parents were to complete each night. This process continued until 14 consecutive days of data was collected. Once all data was collected, the Actiwatch® was removed and the sleep log was collected.

Data Analysis

The dependent variables for all three research questions were sleep efficiency, sleep latency, and actual sleep time. The independent variables were five days of high physical activity and five days of low physical activity for the time frame specified in each research question. For example the independent variables for research question two were five days of high physical activity and five days of low physical activity within one hour of bedtime for each participant's 14 days of data.

For each research question, the dependent variable was averaged to get a single representative number for higher and lower physical activity level. Previous research has suggested that at least five nights of data collection are needed for adequate estimation of sleep start time, wake minutes, and sleep efficiency in children and adolescents (Acebo, Sadeh, Seifer, Tzischinsky, Wolfson, et al., 1999). The data for each variable was then analyzed using a one-way repeated MANOVA.

RESULTS

The results of this study indicate that the participants spent an average of 10 hours and 37 minutes in bed. However, the average amount of actual sleep time for the children was 8 hours and 14 minutes. Additionally, the results indicate that the participants took about 57 minutes to actually fall asleep. Table 1 provides the descriptive statistics regarding the participants sleep patterns

Table 1
Descriptive Statistics of Children's Sleep Patterns

Sleep Variable	Minimum	Maximum	*M*	*SD*
Average Time in Bed	9:33:00	11:54:00	10:37:05	0:40:54
Average Actual Sleep Time	6:22:00	9:22:00	8:14:45	0:49:35
Average Sleep Efficiency	66.29	92.60	77.89	7.73
Average Sleep Latency	0:20:00	2:14:00	0:57:30	0:38:50

Physical Activity Performed Anytime During the Day

The results show that there was no significant effect, Wilk's ? =.63, F (3, 9) = 1.80 ($p > .05$), partial $\eta^2 = .38$, of physical activity on the sleep variables: sleep efficiency, sleep latency and actual sleep time. On average, the participant's high levels of activity were 221.20 and low activity levels were 130.14 with a difference of 86.09. Higher amounts of physical activity had no positive or negative effects on the sleep patterns of the participants. For example, the average sleep latency for higher levels of physical activity was 78.22% compared to an average sleep efficiency of 78.81% for lower levels of physical activity. Table 2 lists the descriptive statistics for sleep efficiency, sleep latency and actual sleep time.

Table 2
Descriptive Statistics of Total Physical Activity on Sleep Variables

Sleep Variable	*M*	*SD*
Sleep Efficiency		
High Days	78.22	7.46
Low Days	78.81	8.12
Sleep Latency		
High Days	0:47:35	0:28:48
Low Days	1:00:20	0:44:28
Actual Sleep Time		
High Days	8:09:55	0:40:54
Low Days	8:21:50	1:00:33

Physical Activity Within One Hour of Bedtime

A MANOVA indicated a significant effect of physical activity on the sleep patterns of the participants, Wilk's ? =.32, F (3, 9) = 6.51 ($p < .05$), partial $\eta^2 = .68$. The follow-up univariate analysis indicated that the amount of physical activity one hour prior to bedtime has a negative effect on sleep efficiency, F (1, 11) = 8.88, ($p < .05$), partial $\eta^2 = .45$. The average sleep efficiency for higher levels of physical activity prior to one hour of bedtime was 76:37% compared to an average sleep efficiency of 79.44% during lower levels of physical activity. This means that the participants had more efficient sleep after lower days of physical activity. On average, the participant's high levels of activity within one hour of bedtime were 397.84 and low activity levels within one hour of bedtime were 139.26 with a difference of 258.57. No significant effect was found on the effect of physical activity within one hour of bedtime on the sleep variables: sleep latency and actual sleep time. For example, the average sleep latency for higher levels of physical activity prior to one hour of bedtime was 1 hour and 9 minutes compared to an average sleep latency of 49

minutes during lower levels of physical activity. Table 3 lists the descriptive statistics for physical activity within one hour of bedtime.

Table 3
Descriptive Statistics of Physical Activity within 1 Hour of Sleep on Sleep Variables

Sleep Variable	*M*	*SD*
Sleep Efficiency		
High Days	76.37	9.23
Low Days	79.44	8.05
Sleep Latency		
High Days	1:09:20	0:54:27
Low Days	0:49:50	0:38:49
Actual Sleep Time		
High Days	8:09:50	0:58:21
Low Days	8:26:55	0:52:21

Physical Activity within 2-3 Hours of Bedtime

The results indicate that there was no significant effect, Wilk's ? =.46, F (3, 9) = 3.50 ($p > .05$), partial $\eta^2 = .54$, of physical activity within 2-3 hours of bedtime on the sleep variables: sleep efficiency, sleep latency and actual sleep time. On average, the participant's high levels of activity within 2-3 hours of bedtime were 447.56 and low activity levels within 2-3 hours of bedtime were 207.75 with a difference of 241.56. Higher amounts of physical activity within 2-3 hours of bedtime had neither positive nor negative effects on the sleep patterns of the participants. For example, the average actual sleep time for higher levels of physical activity within 2-3 hours of bedtime was 8 hours and 8 minutes compared to an average actual sleep time of 8 hours and 20 minutes during lower levels of physical activity within 2-3 hours of bedtime. Table 4 lists the descriptive statistics for sleep efficiency, sleep latency and actual sleep time.

Table 4
Descriptive Statistics of Physical Activity within 2 to 3 Hours of Sleep on Sleep Variables

Sleep Variable	*M*	*SD*
Sleep Efficiency		
High Days	76.69	7.64
Low Days	79.70	7.82
Sleep Latency		
High Days	1:01:15	0:45:36
Low Days	0:49:30	0:35:32
Actual Sleep Time		
High Days	8:08:55	0:47:20
Low Days	8:20:45	0:50:20

DISCUSSION

The results of this study provide evidence that children with autism do have sleep problems. Although these children are in bed approximately 10 ½ hours, they are actually only sleeping approximately eight hours. It is recommended that infants get up to 16 hours, young children (1-4 years) get about 12-15 hours, older children (5-12 years) get about 9-11 hours, adolescents (13-21 years) get about 8 ¼ -9 ½ hours, and adults (21+ years) get about 7-8 hours of sleep per day (Carno, et al., 2003; Keenan, 1999; NINDS, n.d.). Only two of the 12 participants had an average actual sleep time of nine hours for the 14 days of data collection. However, both of these participants were five years old and only getting the recommended amount of sleep for adolescents. Some researchers have suggested that many parents of children with autism tend to over report sleep problems in their children when compared to parents of typically developing children or children with other forms of disabilities (Hering, et

al, 1999; Schreck & Mulick, 2000). However, the results from this study support Honomichl, et al.'s (2002) findings that parents are accurate reporters of their child's sleep problem.

The results from this study show that children with autism have difficulty falling asleep. The average sleep latency for the participants in this study was 57 minutes. A typical young adult should take approximately 10-20 minutes to fall asleep (Keenan, 1999). It has also been suggested that individuals suffering from insomnia take longer than 20 minutes to fall asleep (Lee, 1997). Patzold et al. (1998) completed a study looking at the sleep characteristics of children with autism and Asperger's syndrome. The investigators found that on average it took children in the pervasive developmental disorders group (31 children with autism and seven children with Asperger's) 32 minutes to fall asleep, while it took the control group (36 children without autism) 19 minutes to fall asleep. Richdale and Prior (1995) also found that children with high-functioning autism have a significantly longer sleep latency (30 minutes) when compared to children without autism (18 minutes). The results from the present study support Patzold et al., as well as Richdale and Prior's findings that children with autism have a severe sleep latency problem.

The results of this study indicate that higher levels of physical activity within one hour of bedtime had a negative effect on the participants sleep efficiency. This finding is similar to previous research stating that evening exercise can disrupt sleep (e.g. Keenan, 1999; NINDS, n.d.; Tworoger, Yasui, Vitiello, Schwartz, Ulrich, et al., 2003) and contradictory to another study finding no adverse effects of evening exercise on sleep (Youngstedt et al., 1999). Tworoger et al. (2003) found that sleep in

87 overweight or obese women was disrupted when they participated in moderate-intensity exercise during the evening. Keenan (1999) suggests that exercise in the evening increases an individual's body temperature, which may have a negative effect on sleep. Conversely, Youngstedt et al. (1999) found no effect on sleep, in 16 healthy males, when the exercise program occurred 30 minutes before bedtime. Previous research has provided inconsistent results on the effect of evening exercise on sleep, with some research (e.g. Keenan, 1999; NINDS, n.d.; Tworoger et al., 2003) showing negative effects and others (e.g.Youngstedt et al., 1999) showing no effect. The results of the current study align with the research of Keenan, NINDS, and Tworoger et al. stating that physical activity close to bedtime will have a negative effect on sleep.

While the results of this current investigation showed no overall effect of physical activity on sleep in children with autism, some evidence was provided for the effect physical activity has on sleep within one hour of bedtime. There is one potential explanation for the limited evidence of the effect physical activity has on sleep in children with autism.

The potential explanation for the limited evidence of the effect physical activity has on sleep in children with autism is the possibility of a lack of variability for levels of physical activity. Without variability between high and low levels of physical activity no effect would be seen on sleep. Fourteen days of data collection was used to help eliminate this possibility. This was achieved by splitting the 14 days of data into five high days of activity and five low days of activity. Once the data was split, four days of activity were left to add variability between high and low levels of

physical activity. Lack of variability between activity levels could be the reason no significance was found for total activity. For example, the variability between high and low activity days for total day activity (M = 86.09, SD = 40.76) was much smaller than the variability between high and low activity days within one hour of bedtime (M = 258.57, SD = 114.91). Significance was found for the association between levels of activity within one hour of bedtime and sleep whereas no significance was found for the association between total day activity levels and sleep. Due to the limited effect of physical activity on the participants sleep it is possible that there was not enough variability between high and low levels of physical activity. More days of data collection and controlling levels of physical activity may be needed to increase the variability to determine the effect of physical activity on sleep in children with autism.

A similar situation was seen in the Youngstedt, et al. (2003) study looking at the association of total daily physical activity on typical adult sleepers. The researchers conducted a two part study looking at the day to day effect of physical activity on sleep. In both studies, the most active days and least active days and their effect on sleep were compared. In the first study, there was minimal difference found between most active and least active days and in the second study, no significant difference was found between most and least active days. Youngstedt, et al. determined that a small amount of variability between most active and least active days limited their ability to determine the association between physical activity and sleep. It was suggested that in the future physical activity levels should be manipulated.

The Youngstedt et al. study and the present study provide evidence that more variability may be needed to determine the effect of physical activity on sleep. The present study also suggests the possibility of no association between physical activity and sleep in children with autism. However, it is recommended that a future study be completed looking at the effect of physical activity on sleep in children with autism. Future studies should involve an intervention where physical activity levels are manipulated. Intervening may aid in distinguishing between higher and lower levels of physical activity.

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CHAPTER 3: SUMMARY

The following summary will provide a discussion for each of the research questions that were presented in the introduction, as well as provide suggested future research directions.

RESEARCH CONCLUSIONS

1) Would the amount of physical activity during the day have an association with sleep efficiency, sleep latency, and actual sleep time in children with autism?

The results show that total physical activity levels have no association with sleep efficiency, sleep latency, and actual sleep time in children with autism. More research is needed to determine if there is an effect of physical activity on sleep problems in children with autism.

2) Would the amount of physical activity within one hour of bedtime have an association with sleep efficiency, sleep latency, and actual sleep time in children with autism?

It was found that physical activity within one hour of bedtime had a significant effect, Wilk's ? = .32, ($p < .05$), on sleep in children with autism. The follow-up univariate analysis indicated that the amount of physical activity one hour prior to bedtime has a negative effect on sleep efficiency, $F(1, 11) = 8.88$, ($p < .05$), with higher levels of activity being worse for sleep. No significant effect was found for the effect of physical activity within one hour of bedtime on sleep latency and actual sleep

time in children with autism. The results provide evidence that engaging in physical activity close to bedtime is disruptive for sleep in children with autism.

3) Would the amount of physical activity within 2-3 hours of bedtime have an association with sleep efficiency, sleep latency, and actual sleep time in children with autism?

It was found that physical activity within 2 to 3 hours of bedtime had no effect on sleep efficiency, sleep latency, and actual sleep time in children with autism. These results show that within 2 to 3 hours of bedtime sleep will neither be positively or negatively affected in children with autism.

FUTURE RESEARCH DIRECTSIONS

Based on the results of this investigation and the lack of previous research in this area, several suggestions for future investigations are made. The first suggestion for future research is to conduct a study, using a physical activity intervention to determine the effect physical activity has on sleep in children with autism. This would allow investigators to control physical activity levels for the participants. Controlling physical activity levels would then increase the difference between high and low levels of activity. It would also be beneficial to collect data on the sleep patterns prior to the physical activity intervention being implemented. Knowing how the children sleep before starting the study would allow for a better understanding of what improvements, if any, might be seen after intervening with physical activity.

The second suggestion for future research would be to increase the sample size. In this study, the sample was limited to 12 participants. With an increased sample size, there is a greater likelihood that an existing small effect would be seen.

The last suggestion for future research is to increase the number of consecutive days of data collection. Adding more days may help eliminate the possibility of a lack of variability in physical activity levels, showing the effect physical activity has on sleep in children with autism.

The effect physical activity has on sleep in children with autism still remains unclear. Due to the possible limitations of this study, further research is needed in the area of sleep problems in children with autism.

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APPENDICES

APPENDIX A - REVIEW OF THE LITERATURE

The purpose of this review is to provide the reader with information on the areas of sleep, measuring sleep, autism, sleep problems in children with autism, the benefits of physical activity/exercise, and the effects of physical activity/exercise on sleep. This material will provide a rationale for the study.

Sleep

Sleep is a complex process comprised of many physiological and behavioral components (Carno, et al., 2003; Lyznicki & Williams, 1998). During sleep an individual becomes unresponsive and disengaged from the environment (Carno, et al., 2003; Keenan, 1999; Landis, 2002; Youngstedt, 2000). There are five phases of sleep that the body passes through during the night: stages 1, 2, 3, and 4 or non-Rapid Eye Movement (NREM) and phase 5, Rapid Eye Movement (REM) (Carno, et al., 2003; Driver & Taylor, 1996; Keenan, 1999; Landis, 2002; Lee, 1997; NINDS, n.d.; Shapiro, et al., 1975; Youngstedt, 2000). NREM, which is thought to be restorative sleep for the body, is characterized by a physiological calmness and accounts for about 75% of sleep, while REM, which is thought to be restorative sleep for the brain, makes up about 25% of the sleep period and is the time in which dreaming occurs (Keenan, 1999; Rodehn Fox, 1999; Youngstedt, 2000).

The pattern and stages of sleep signify the individual's depth of sleep (Carno, et al., 2003; Landis, 2002; Lee, 1997). The NREM pattern of sleep begins in stage 1 with approximately 1-7 minutes of light sleep during which the individual can be

wakened easily (Carno, et al., 2003; Landis, 2002; Lee, 1997; NINDS, n.d.; Youngstedt, 2000). Stage 1 sleep is classified as a light, transitional phase when an individual goes from waking to sleep (Driver & Taylor, 1996). As the individual progresses through stage 2, sleep begins to get deeper. Stage 2 is classified as the true onset of sleep or sleep onset latency (Driver & Taylor, 1996). Stages 3 and 4 make up deep sleep in which it is hard to awaken a person (Carno, et al., 2003; Lee, 1997; NINDS, n.d.). Collectively, stages 3 and 4 are classified as slow wave sleep (SWS) (Driver & Taylor, 1996). Slow wave sleep is characterized by high amplitude low frequency waves (Driver & Taylor, 1996). When an individual reaches the end of SWS they move back into the lighter stages of sleep and into REM sleep (Driver & Taylor, 1996). REM sleep begins in phase 5 and is characterized by rapid, shallow and irregular breathing, a period of limb muscle paralyzation or low muscle tone, and rapid eye movement (Driver & Taylor, 1996; Keenan, 1999; Landis, 2002; Lee, 1997; NINDS, n.d.). This phase is another period of lighter sleep in which the activity is similar to that of stage 1 (Driver & Taylor, 1996). During REM sleep, children have the tendency to wet the bed, experience night terrors, or sleepwalk (NINDS, n.d.). The whole sleep cycle is known as the NREM-REM cycle and repeats continuously throughout the night at approximately 90-minute intervals (Driver & Taylor, 1996; Keenan, 1999; Rodehn Fox, 1999; Youngstedt, 2000). The number of NREM-REM cycles that an individual goes through during the night is dependent on the cycle length and total sleep time (Driver & Taylor, 1996). As morning draws near deep sleep begins to decrease and by morning most of an individual's sleep occurs in stages 1, 2, and REM (NINDS, n.d.; Rodehn Fox, 1999).

According to NINDS (n.d.), sleep is beneficial for an individual's overall health and well-being. Sleep is an active process that affects an individual's daily functioning and physical and mental health. The amount of sleep an individual needs varies from person to person (Keenan, 1999). It is dependent on many different factors. One of these factors is age (Carno, et al., 2003; Keenan, 1999; Lee, 1997). It is recommended that infants get up to 16 hours, teenagers get up to 9 hours, and adults get about 7-8 hours of sleep per day (Carno, et al., 2003; Keenan, 1999; NINDS, n.d.). Sleep deprivation can result in impairment in judgment, reaction time, and many other functions (Landis, 2002; NINDS, n.d.). Deep sleep is known to reduce activity in the parts of the brain that controls emotions, decision-making, and social interactions, suggesting that deep sleep could help maintain emotional and social functioning throughout the daytime (NINDS, n.d.).

Measuring Sleep

Sleep Questionnaires

Sleep questionnaires are commonly used to measure sleep problems in an individual's natural environment (Johnson, 1996). Parents or the individual complete the questionnaires. The data are then evaluated by an investigator to determine if the individual has a sleep problem. According to Hering, et al. (1999), the parameters for the questionnaires are based on what might be found from actigraphs. Some of the data that can be obtained from sleep questionnaires are a) time of sleep onset (the time the individual falls asleep), b) sleep offset time (the time the individual wakes in the morning), c) night arousals (termination of sleep), and d) total sleep duration during

the night (Hering, et al., 1999). Data from the sleep questionnaire are subjective, which has resulted in the belief that the use of this method alone is not sufficient because accurate information may not be provided (Youngstedt, 2000). Sleep questionnaires can provide important information for editing raw data from the actigraph (Klosh, Gruber, Anderer, & Saletu, 2001).

Actigraphs

Actigraphs are another method used to measure sleep. The actigraph is a small, portable device that is used to measure movement (American Sleep Disorders Association, 1995; Ancoli-Israel et al., 2003; de Souza et al., 2003; Jean-Louis et al., 1999; Pollak et al., 2001; Sadeh et al., 1995; Sforza et al., 1999). Sleep is inferred by an absence of activity or movement because in general there is less limb movement during sleep than wakefulness (Hauri & Wisbey, 1992; Mullaney, Kripke, & Messin, 1980). An individual wears the device on the nondominant wrist, waist, or leg. Data are recorded in intervals known as epochs, which are represented in minutes or seconds. An epoch length is limited to a maximum of 1 minute (American Sleep Disorders Association, 1995). The epoch-by-epoch samples are stored in the actigraph for a predetermined amount of time and then downloaded into a computer program so they can be displayed, scored, analyzed, and converted into sleep parameters (American Sleep Disorders Association, 1995). This method is becoming a more common form of measurement because it can be done in the individual's natural environment (Acebo et al., 1999; Jean-Louis et al., 1997; Mullaney et al., 1980; Sadeh et al., 1994; Sadeh et al., 1995).

The appropriateness and validity of the actigraph has been questioned by some researchers on several issues: a) device placement and sensitivity, b) breathing movement, and c) positioning during sleep (Jean-Louis et al., 1996). Jean-Louis et al. (1997) conducted a study to test the placement of the actigraph in which 11 volunteers wore actigraphs on their dominant and nondominant wrist for one night. The data were analyzed using the Actigraph Data Analysis Software with the results showing no significant difference between the dominant and non-dominant wrist. Violani, Testa, & Casagrande (1998) also conducted a study to determine if there was a difference between actigraph placement between the dominant and nondominant wrists. Sixteen right-handed volunteers with no sleep problems wore actigraphs for 48 consecutive hours. For the first 24 hours, half of the subjects wore actigraphs on each wrist while the other half wore actigraphs on each ankle. During the second 24 hours, the actigraphs were worn in an inverse order. It was found that in the first part of the night the nondominant hand has superiority, but as the night progresses the dominant hand has the advantage. This pattern occurs throughout the night and no difference was found in the overall motor activity.

This method of measurement can be more convenient than the use of the polysomnography (PSG), which is considered the gold standard of assessing sleep (Paavonen, Fjallberg, Steenari, & Aronen, 2002; Lockley, Skene, & Arendt, 1999; Youngstedt, 2000). Although the PSG can provide detailed information about sleep physiology, this method is expensive and cumbersome when used to detect sleep or no sleep (Blood, Sack, Percy, & Pen, 1997). Jean-Louis et al. (1997) noted strong correlation between the PSG and the actigraph with the correlation ranging from .89 to

.98. The actigraph is a good alternative to the PSG because actigraph is a) easy to use, b) objective, c) unobtrusive, d) cost effective, e) usable for long-term studies, and f) not as limited as the PSG in long-term studies of sleep (Dagan et al., 1997; Pollak et al., 2001; & Jean-Louis et al., 1997). The actigraph recordings can be conducted over days or weeks under natural conditions, whereas the PSG must be conducted in a sleep lab (American Sleep Disorder Association, 1995).

The actigraph does have some major limitations. One major limitation is the actigraphs lack of precision (American Sleep Disorder Association, 1995). Inaccurate data will be obtained if an individual lies still for long periods of time while they are still awake. Another limitation is that there may be reliability problems due to uncontrolled removal of the actigraph or artifacts affecting an individual's body movement (Sadeh, Sharkey, & Carskadon, 1994). A third major limitation of the actigraph is that it cannot reliably differentiate between the stages of sleep (American Sleep Disorder Association, 1995). The American Sleep Disorder Association (1995) suggests that the actigraph is most accurate when used for the differentiation between major periods of sleep and waking.

Autism

The term autism emerged in 1943 when child psychiatrist Leo Kanner observed social aloofness in a group of young children (Towbin, et al., 2002). Autism falls under the umbrella term Pervasive Developmental Disorders (American Psychiatric Association, 1994). According to the American Psychiatric Association (1994), Pervasive Developmental Disorders "are characterized by severe and

pervasive impairment in several areas of development: reciprocal social interaction skills, communication skills, or the presence of stereotyped behavior, interests, and activities" (p. 65). There are five classifications of pervasive developmental disorders. These five classifications are: a) autistic disorder, b) rett's disorder, c) childhood disintegrative disorder, d) asperger's disorder, and e) pervasive developmental disorders not otherwise specified (American Psychiatric Association, 1994). All of these disorders usually appear within the first few years of life and can be associated with varying degrees of mental retardation (American Psychiatric Association, 1994).

Autism is a form of developmental disability that is evident before age 3 and affects an individual's verbal and nonverbal communication and social interaction (American Psychiatric Association, 1994; Towbin, et al., 2002). This condition affects an individual throughout life. Cognitively, individuals with autism range from profound mental deficiency to superior ability. Children with autism show deficits in their range of interests and activities (American Psychiatric Association, 1994; Rapin & Katzman, 1998). Even though there is the possibility for cognitive delay, some of these individuals can have great rote memories and talent with puzzles, calculations, music, and art (Rapin & Katzman, 1998).

The prevalence of autism has been shown through epidemiological studies to occur in approximately 2-5 per 10,000 individuals (American Psychiatric Association, 1994). According to Yeargin-Allsopp, et al. (2003), three studies conducted in the 1980s and early 1990s showed prevalence rates of approximately 4 per 10,000 children. However, according to Rapin (2001) epidemiological studies have found the prevalence to be 1-1.3 per 1000 and 1-2 per 500 if the mildly affected children are

included into the studies. The ratio of autism in boys to girls is 4:1 with an increased risk among siblings (American Psychiatric Association, 1994; Rapin, 2001).

The diagnosis of autism is based on criteria that are comprised of communication, social interaction, and behavioral deficits (American Psychiatric Association, 1994; Gillberg, 1993). Many children with autism, especially at the toddler and preschool levels, exhibit inadequate language and play skills, aloofness, tantrums, and behavioral rigidity (Rapin & Katzman, 1998). In some children communication does develop but it is usually choppy, hindering the child's ability to engage in dialogue (Rapin & Katzman, 1998). Communication development is also seen to regress around 21 months in some of these children (Rapin & Katzman, 1998). Children with autism who develop language do not always understand it or know how to use it as a form of communication (Gillberg, 1993).

In children with autism, behavioral rigidity takes the form of atypical social behavior. These individuals engage in stereotypical behavior, need strict routine, and have other ritualistic phenomena that they engage in (Gillberg, 1993). Play patterns in children with autism are usually defective, unimaginative, manipulative, and solitary (Rapin & Katzman, 1998). These children can also be severely hyperactive and disorganized.

There are many dysfunctional behaviors apparent in some children with autism. Some of these dysfunctional behaviors are a) self-stimulation, b) self-injury, c) poor eye contact, d) insensitivity to pain, e) auditory-perceptual abnormalities, f) abnormal reaction to pain, touch, heat, and cold, g) destructiveness, and h) sleeping and eating problems (Gillberg, 1993; Rapin, 2001). Children with autism engage in

different motor manifestations. One type of manifestation is repetitive purposeless movements or stereotypes such as flapping, twirling, twisting of the fingers, or waving fingers in front of the eyes (Rapin & Katzman, 1998).

Autism and Sleep Problems

One common problem that children with autism experience as much as, or more frequently than children with other forms of disabilities, is difficulty sleeping (Hering et al., 1999; Hoshino et al., 1984; Johnson, 1996; Patzold et al., 1998; Richdale, 1999; Richdale & Prior, 1995; Schreck & Mulick, 2000; Thirumalai et al., 2002; Weiskop et al., 2001). Hoshino, et al. (1984) found that in a sample of 75 children with autism, 65% had some form of sleep disturbance, with a higher rate in those children with autism who were cognitively less developed.

More specifically, children with autism have frequent problems with settling, falling asleep, maintaining sleep throughout the night, irregular sleep-wake patterns, bed wetting, poor sleep, and early waking (Johnson, 1996; Patzold et al., 1998; Richdale, 1999; Thirumalai et al., 2002; Weiskop et al., 2001). These sleep problems have a negative effect on the family and on the individual's behavior or daytime performance the following day (Honomichl et al., 2002; Hoshino et al., 1984; Johnson, 1996; Patzold et al., 1998; Richdale, 1999; Thirumalai et al., 2002; Weiskop et al., 2001). Hoshino et al.'s (1984) study found that the following daytime behavior or performance problems took the form of taking a long nap, losing their temper, becoming hyperactive, becoming inactive, and succumbing to isolation. Additionally, sleep problems add more stress onto an already stressed family life. The child's sleep

problem will disrupt the entire families sleep, add stress on the family, result in an increase in irritability, and cause a reduction in the families ability to deal with the challenging behaviors associated with autism (Honomichl, et al., 2002; Sweeney et al., 2003). It has been suggested that parents of children with autism who have sleep problems over report the problem and describe more problems in their children than do parents of normally developing children or children with other forms of disabilities (Hering, et al, 1999; Schreck & Mulick, 2000). However, Honomichl et al. (2002) conducted a study assessing the sleep-wake behaviors in 100 children with autism between the ages of 2 and 11 years. In this study, parents were asked to complete a sleep diary and sleep habit questionnaire over a 12-week period. The results showed that parents are accurate reporters of sleep problems in children with autism.

There is currently no known cause for the sleep problems in children with autism. However, there are several possible explanations for these sleep problems. One reason is the children's lack of understanding of social and environmental cues (Johnson, 1996; Patzold et al., 1998; Richdale, 1999). According to Richdale (1999), "routine and social cues are thought to help young infants develop stable sleep-wake patterns" (p. 62), which means that because children with autism have deficits with social cues they may not develop a sleep-wake schedule. Many of these children are sensitive to environmental stimuli, such that if there is a change in the environment before bedtime their sleep pattern may be negatively affected. Another reason why these children may experience problems with sleep is due to stereotypical behaviors such as flapping, twirling, twisting of the fingers, or waving fingers in front of the eyes (Johnson, 1996; Richdale, 1999). Most children with autism who engage in these

behaviors find it pleasurable, become aroused, and could become distressed if the behavior is interrupted, which happens when it is time to go to sleep (Johnson, 1996; Richdale, 1999). Because these children become aroused by these stereotypical behaviors it may be difficult for them to sleep. Lastly, sleep problems can be due to lack of bladder and bowel control, which can result in the child awakening during the middle of the night (Johnson, 1996).

Currently, only two methods are being used to alleviate sleep problems in children with autism. These methods are traditional behavioral intervention and pharmacological treatment (Johnson, 1996; Richdale, 1999). Traditional behavioral intervention takes the form of applied behavior analysis (Johnson, 1996). Some types of traditional behavioral intervention used are a) keeping a consistent bedtime routine, b) scheduled awakenings, c) extinction of the negative behavior, and d) positive reinforcement for appropriate behaviors (Johnson, 1996; Richdale, 1999). These methods of intervention require consistency, which can be difficult for some parents to implement. Although these methods have been repeatedly documented as working with children with and without intellectual disabilities experiencing sleep problems, there is little support showing that the approach works with children with autism (Weiskop et al., 2001). Pharmacological treatment is the other form of intervention that has been used to help children with sleep problems (Johnson, 1996; Richdale, 1999). Medicine is used to help the individual fall asleep and keep the child sleeping throughout the night (Johnson, 1996). Types of medicine that are used are benadryl and other antihistamines that have sedative effects (Johnson, 1996). However, pharmacological treatment can be expensive and the long-term efficacy of this

approach is not certain (Montgomery & Dennis, 2002). Also, using pharmacological treatment can cause tolerance, dependency, negative side effects, and mortality (Montgomery & Dennis, 2002; Youngstedt, Kripke, & Elliott, 1999). In addition, most children with autism are already on a lot of medication, which may make dosage and monitoring challenging.

Effects of Physical Activity/Exercise on Sleep

Physical activity is associated with many physical and psychological benefits and is essential for a healthy life (Amisola & Jacobson, 2003; Gabler-Halle et al., 1993; Healthy People 2010; Klepper, 2003; Macera et al., 2003; Shephard, 1995; Sothern et al., 1999). The physiological benefits of physical activity for humans are a) decreased risk of death from heart disease, b) lower risk of diabetes, c) decreased risk of colon cancer, d) prevention of high blood pressure, e) increased muscle and bone strength, f) increased lean muscle, g) decrease of body fat, and h) weight control (Amisola & Jacobson, 2003; Healthy People 2010; Klepper, 2003; Macera et al., 2003; Shephard, 1995; Sothern et al., 1999). The psychological benefits of physical activity for humans are a) reduced symptoms of depression, b) reduced symptoms of anxiety, c) improved self-efficacy and confidence, d) reduced tension, e) reduced hostility, and f) improvement in overall mood and satisfaction in life (Gabler-Halle et al., 1993; Healthy People 2010; Klepper, 2003; Shephard, 1995; Sothern et al., 1999). Healthy People 2010 recommends that children get about 60-minutes of physical activity per day. Physical activity is essential and aids in improving a person's quality of life.

Physical activity and exercise are terms that can be confused. Physical activity is body movement that is being produced by the skeletal muscles and results in energy expenditure that can be classified as either moderate or vigorous (Healthy People 2010). Both moderate and vigorous physical activity involves the large muscle groups. Moderate physical activity includes activities such as brisk walking, cycling, gardening, etc., while vigorous physical activity includes more intense activities such as running, lap swimming, cycling, etc. (Healthy People, 2010). Exercise, a form of physical activity, involves planned, structured, and repetitive body movements that are done to increase or maintain an individual's fitness level (Healthy People 2010).

Physical activity may be a potential treatment for sleep problems. As listed previously, the benefits of physical activity are numerous, giving this form of treatment a better appeal than some treatments already available (Youngstedt, 2000; Youngstedt et al., 1997). One benefit of physical activity is that it helps reduce anxiety, which is important because anxiety can disrupt sleep (Youngstedt, 2000). Another benefit of physical activity is that it is inexpensive, while using medicine as a treatment can become expensive and hazardous to a persons health (O'Connor & Youngstedt, 1995; Youngstedt, 2000; Youngstedt et al., 1997). A third benefit is that physical activity might not only enhance sleep, but it is a major contribution to an increase in an individual's quality of life (Montgomery & Dennis, 2002).

Although there have been some studies completed on physical activity and sleep, research in this area is limited. Additionally, these studies are usually of poor methodological quality and focus on individuals who do not have sleep problems (Youngstedt, 2000; Youngstedt et al., 1997). Experimental research needs to be

completed on the efficacy of exercise for sleep enhancement. Research needs to focus on those individuals who have sleep problems and have room for sleep improvement (Youngstedt et al., 1997). Due to the limited number of studies completed on physical activity and sleep, more research is needed.

The Youngstedt et al. (1997) meta-analysis provides some evidence about the area of physical activity and its effect on sleep. The meta-analysis reviewed 38 studies with a total of 401 subjects, which yielded 211 effect sizes. The mean effect sizes calculated were a) sleep onset latency, b) slow-wave sleep (SWS), c) rapid eye movement (REM), d) REM latency (REM-L), e) total sleep time (TST), and f) wakefulness after sleep onset. Youngstedt et al.'s results showed that acute exercise has a small to moderate effect on sleep. However, most of the published studies in the meta-analysis focused exclusively on individuals without sleep problems. This is a major limitation because it is possible that the effect of exercise on individuals with sleep problems is being underestimated. Youngstedt et al.'s meta-analysis provides supporting evidence that more studies that focus on individuals with sleep problems need to be conducted.

Several studies on the benefit of physical activity/exercise on sleep were recently conducted. Tanaka et al. (2001) studied a group of six elderly people who were having trouble sleeping. The interventions used were short naps after lunchtime and moderate intensity exercise at night. The intervention lasted four weeks and data were collected by use of actigraphs. The results showed an increase in sleep efficiency indicating that sleep quality was improved in the elderly with sleep problems following the short nap and moderate intensity exercise intervention. The

second study, Namazi et al. (1995), found that in a sample of 11 patients with Alzheimer's, 73% of them had improved sleep quality after participating in an exercise/movement program. The third study, Sherrill, Kotchou, & Quan (1998), studied a group of subjects that participated in a survey and answered questions about exercise and sleep disorders. There were six questions asked about exercise and physical activity. Included in the analyses were 319 men and 403 women. The analyses was completed using the multivariate logistic regression model with measures of sleep disorders as the dependent variables and measures of exercise and physical activity as the independent variables. The results showed that participation in a regular exercise or activity program at least once a week significantly reduced sleep disorders. Kubitz, Landers, Petruzzello, & Han (1996) completed a meta-analytic review on the effects of acute and chronic exercise on sleep. Out of the 73 studies that they located, 64 of these studies matched the inclusion criteria and contained information that could be used in their review. For these 64 studies, effect sizes were calculated for 38, mean differences were derived for 12, findings were summarized for 14 because the means and standard deviations were unavailable, and 9 were excluded. Their findings showed that there was a significant acute and chronic effect of exercise on sleep. It was found that sleep after participating in exercise was longer, deeper, and more readily achieved, which was the case for both long term and short term involvement in an exercise program. The findings from Tanaka, Namazi, Sherrill, and Kubitz support the basis that physical activity/exercise does have a positive impact on individuals who have sleep problems and proves to be a useful treatment for individuals with sleep problems.

Conversely, Youngstedt et al. (2003) completed a study that showed exercise has no effect on sleep in individuals without sleep problems. In the study, the effect of exercise on sleep in 31 healthy college students who had no sleep problems was examined. The data were self-reported and lasted for 105 consecutive days. The results showed no significant benefit of exercise on sleep in these individuals. The second part of the study examined the same effect on 71 adults that were physically active with the majority having no sleep problems. Actigraphs and sleep diaries were used in this study and also showed no significant benefit of exercise on sleep. Bevier, Bliwise, Bliwise, Bunnell, & Horvath (1992), conducted a study on the sleep patterns of older adults and the effects of exercise. The participants in this study were 8 women and 6 men, all of whom were healthy and physically active, with a mean age of 64 years. In this study, the participants spent 5 consecutive nights in a lab having their sleep measured by PSG. On day 4, the participants were involved in an exercise intervention. The results showed that there was no improvement on sleep, but it did not disrupt it either. However, subjectively, sleep quality was improved. Bevier et al. feel that it is unclear as to what level of exercise is needed to produce an effect and whether this level is different for young and old.

Furthermore, it is questionable as to the best time to engage in physical activity. It is believed by some that exercise performed within 3 to 4 hours of bedtime can be detrimental to sleep while others state that exercising 2 to 4 hours before bedtime will help sleep (Keenan, 1999; NINDS, n.d.; Youngstedt, 1997). Other research has found exercise to be of benefit 30-60-minutes prior to sleep (Youngstedt, 2000). Youngstedt et al. (1999) conducted a study examining the affect of vigorous

late-night exercise on sleep in 16 healthy male cyclists. The exercise program consisted of 3 hours of cycling and bedtime occurred 30 minutes after the completion of the exercise program. The results of this study showed no alteration or effect on sleep. Conversely, researchers studied the effect of either an aerobic exercise program or stretching and relaxation program on sleep in 173 overweight or obese women (Tworoger et al., 2003). Over a 1 year period, they found that the women who participated in at least 225 minutes a week of aerobic exercise in the morning were less likely to have difficulty sleeping when compared to women in the same group who exercised 180 minutes a week. They also found that women who exercised just as much, but in the evening, slept worse than the women in the less active group.

The duration/amount of physical activity and its effect on sleep is another area of controversy. In Namazi et al.'s (1995) study the exercise program intervention lasted 40-minutes and sleep quality was increased. Youngstedt et al. (1997), found that if the duration of the exercise program lasts longer than one hour an individual's total sleep time will be increased. These areas of variation may be dependent on the individual.

The limited amount of evidence about the benefits of physical activity/exercise on individuals with sleep problems suggests that future research be completed to determine if there is an effect on individuals who have sleep problems.

APPENDIX B – IRB APPROVAL

INSTITUTIONAL REVIEW BOARD

OREGON STATE UNIVERSITY

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TO: Joonkoo Yun,
Exercise and Sport Science

RE: The Effect of Physical Activity on Sleep in Children with Autism
(Student Researcher: Kristine Hagar)

IRB Protocol No. 2428

The referenced project was reviewed under the guidelines of Oregon State University's Institutional Review Board (IRB). The IRB has **approved** the application. This approval will expire on 2/2/2005. This new request was reviewed at the Expedited level. A copy of this information will be provided to the full IRB committee.

Enclosed with this letter please find the approved informed consent document for this project, which has received the IRB stamp. This information has been stamped to ensure that only current, approved informed consent forms are used to enroll participants in this study. All participants must receive the IRB-stamped informed consent document.

- Any proposed change to the approved protocol, informed consent form(s), or testing instrument(s) must be submitted using the MODIFICATION REQUEST FORM. Allow sufficient time for review and approval by the committee before any changes are implemented. Immediate action may be taken where necessary to eliminate apparent hazards to subjects, but this modification to the approved project must be reported immediately to the IRB.
- In the event that a human participant in this study experiences an outcome that is not expected and routine and that results in bodily injury and/or psychological, emotional, or physical harm or stress, it must be reported to the IRB Human Protections Administrator within three days of the occurrence using the ADVERSE EVENT FORM.
- If a complaint from a participant is received, you will be contacted for further information.
- Please go to the IRB web site at:
http://osu.orst.edu/research/RegulatoryCompliance/HumanSubjects.html to access the MODIFICATION REQUEST FORM and the ADVERSE EVENT FORM as needed.

Before the expiration date noted above, a Status Report will be sent to either close or renew this project. It is imperative that the Status Report is completed and submitted by the due date indicated or the project must be suspended to be compliant with federal policies.

If you have any questions, please contact the IRB Human Protections Administrator at IRB@oregonstate.edu or by phone at (541) 737-3437.

for Laura K. Jensen Date: 2/3/04
Drs. Courtney Campbell and Wayne Kradjan
Institutional Review Board Co-Chairs

pc: 2428 file

APPENDIX C – INVITATIONAL LETTER

DEPARTMENT OF
EXERCISE AND
SPORT SCIENCE

Date

To Whom It May Concern:

If your child has autism and a sleep problem, you and your child are invited to participate in a research study conducted in the Movement Studies in Disability program. Sleep is an active process that affects an individual's daily functioning. One common complaint from parents of children with autism is that their children lack sufficient sleep. The purpose of this study is to examine the effects of physical activity among children with autism who have sleep problems.

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Currently, two forms of intervention are being used to decrease sleep problems in children with autism, behavioral intervention and pharmacological treatment. Traditional behavioral intervention uses procedures such as following a consistent bedtime routine and extinction. However, there is little evidence that behavioral intervention works with treating sleep problems in children with autism. Pharmacological treatment is used as a method of treatment by giving these children medicine such as benadryl and other antihistamines with sedative effects. This method is not recommended because it can be expensive and many children with autism are already on a number of medications. There is a critical need to find a new, safe, and effective method of treating sleep problems in children with autism.

Physical activity may be one effective and safe solution for treating sleep problems in children with autism. However, there is lack of scientific evidence demonstrating the effectiveness of physical activity as a treatment for sleep problems. The results of this study will provide valuable information related to a possible alternative treatment for sleep problems in children with autism.

Participation in this study is strictly on a volunteer basis. If your child with autism is between 3-12 years of age and has been diagnosed with, or you feel he or she has, a sleep problem, then you and your child may be able to participate in this study. During the study your child's physical activity and sleep patterns will be monitored for a 14 day period. If you would be interested in having your child participate in this study please contact Kristine Hagar by phone at (541) 737-6919 or by email at hagark@onid.orst.edu.

Telephone
541-737-2631

Fax
541-737-6613

Thank you very much.

Sincerely,

Kristine A. Hagar

Joonkoo Yun, Ph.D.
Assistant Professor

APPENDIX D – INFORMED CONSENT DOCUMENT

DEPARTMENT OF
EXERCISE AND
SPORT SCIENCE

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Project Title: **The Effect of Physical Activity on Sleep in Children with Autism**

Investigators: Kristine Hagar and Joonkoo Yun, Department of Exercise and Sport Science

PURPOSE

You and your child are invited to participate in a research study conducted in the Movement Studies in Disability program. Sleep is an active process that affects an individual's daily functioning. One common complaint from parents of children with autism is that many children lack sufficient sleep. Physical activity may be one effective and safe solution for treating sleep problems in children with autism. The purpose of this study is to examine the effects of physical activity on children with autism who have sleep problems. The following sections summarize what you and your child will be asked to do; the potential risks and benefits of this study; and your rights as a volunteer so that you can make a decision as to whether you will participate in this study. The intended uses of the project are to complete partial requirements for a Master of Science degree and to publish the results in a journal.

PROCEDURES

If you agree to be involved in this study, your child's participation will require 3 weeks. During the first week, your child will be asked to wear a plastic wrist band on his/her non-dominant wrist. This will be done so the child will become accustomed to wearing an object on his or her wrist. During the second and third weeks, your child will be asked to wear an actigraph on his/her non-dominant wrist. An actigraph is a small watch-like device (one inch square) that measures sleep efficiency and body movement. During this time, your child should follow his/her normal daily routine. It is expected that your child will wear the actigraph for the entire period. Also, you will be asked to complete a daily log that records your child's sleep pattern and physical activity. Completing the log will take approximately 10 minutes each day. Every five days, after your child starts wearing the actigraph, we will contact you to collect the log and download data from the actigraph. The meeting will take place at a convenient location for you and your child. During the meeting, we will be able to answer any of your questions, and the meeting will be approximately 15 minutes.

RISKS

There are no foreseeable risks to participating in this research project.

BENEFITS

At the end of this study, you and your child will receive a copy of the sleep efficiency report. In addition to the report of your child's sleep efficiency, participation in this study will provide valuable information related to a possible alternative treatment for sleep problems in children with autism.

COSTS AND COMPENSATION

You will not have any costs for your child's participation in this research project. You will not be compensated for your child's participation in this research project.

CONFIDENTIALITY

Records of your child's participation in this research project will be kept confidential to the extent permitted by law. In the event of any report or publication from this study, your child's identity will not be disclosed. Results will be reported in a summarized manner in such a way that your child cannot be identified.

VOLUNTARY PARTICIPATION

Having your child take part in this research study is voluntary. You may choose not to have your child take part at all. If you agree to have your child participate in this study, you may stop your child's participation at any time. If you decide not to have your child take part, or if you stop having your child participate at any time, your decision will not result in any penalty or loss of benefits to which you may otherwise be entitled. Data that is collected from the participant prior to withdrawal will not be included in the study results.

QUESTIONS

Questions are encouraged. If you have any questions about this research project, please contact: Kristine Hagar, at (541) 737-6919, or by email at hagark@onid.orst.edu or J.K. Yun, at (541) 737-8584, or by email at jk.yun@oregonstate.edu. If you have questions about your child's rights as a participant, please contact the Oregon State University Institutional Review Board (IRB) Human Protections Administrator, at (541) 737-3437 or by e-mail at IRB@oregonstate.edu.

Your signature indicates that this research study has been explained to you, that your questions have been answered, and that you agree to have your child take part in this study. You will receive a copy of this form.

Participant's Name (printed):

_____

_____ _____
Name of Parent/Guardian (printed) (Date)

_____ _____
(Signature of Parent/Guardian or Legally Authorized Representative) (Date)

RESEARCHER STATEMENT

I have discussed the above points with the participant or, where appropriate, with the participant's legally authorized representative, using a translator when necessary. It is my opinion that the participant understands the risks, benefits, and procedures involved with participation in this research study.

_____ _____
(Signature of Researcher) (Date)

APPENDIX E – SLEEP LOG

The Effect of Physical Activity on Sleep in Children with Autism
Oregon State University

SLEEP LOG

Thank you for participating in this study. Sleep problems are a common issue that children with autism experience. Many of these children experience difficulty falling asleep, maintaining sleep throughout the night, and poor sleep. We would like to examine a possible effective intervention strategy for dealing with sleep problems in children with autism. This intervention strategy is physical activity.

Your cooperation is a critical part of this study. Please fill out the information as accurately as possible.

Demographic Information:

Name: _____ Date of Birth: _____

Age: _____ Male or Female: _____

Date of Diagnosis of Autism: _____ Height: _____

Diagnosis Made By: _____ Weight: _____

Does your child have a sleep problem? Yes No

If yes, what current form of treatment is being used? _____

_____

_____

Does your child take any medication? Yes No

If yes, please name the medication your child is on: _____

_____

_____

List any typical behavioral issues: _____

_____

Please complete the following:

Date			
Bed Time (Time the lights went off).			
Wake Time (Time the child gets out of bed the next day).			
Did the child wake up during the night and get out of bed? If so, how many times and how long did each time last?			
Did the child take a bath/shower?	BATH	SHOWER	NONE
Time of the bath/shower?			
How long did the bath/shower last?			
Did the child take a nap during the day?	YES		NO
Time of the nap?			
How long did the nap last?			
Did the child participate in any physical activity today (e.g. school P.E., walk, IMPACT, etc.)? List activity.			
Time when child participated in physical activity and how long it lasted.			
Did the child exhibit any unusual behaviors today?	YES		NO
What behaviors were exhibited and at what time during the day? Was it during physical activity?			
What mood was the child in today (good, bad, etc.)? Explain.			
Was today a school day or a weekend?	SCHOOL		WEEKEND
Was the child feeling sick today (cold, flu, etc.)?	YES		NO
Did the child have any therapy sessions today (PT, OT, speech, etc.)? List therapy session.			
Did the family do anything out of the ordinary today (family trip, movie, vacation, etc.)? Explain.			

ANY OTHER COMMENTS: