Short Term Examination of Physical Activity and Sleep Quality with Children with Autism Spectrum Disorder

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by

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Abstract

Children diagnosed with Autism Spectrum Disorder (ASD) may not be meeting the recommended amounts of physical activity (PA) or obtain a sufficient amount of sleep, however, few studies have objectively compared PA, sedentary behavior, and sleep quality between typically developing (TD) youth, and youth with ASD. Therefore, the purpose of this study was to compare levels of PA, sedentary behavior, and sleep quality between youth with ASD and TD youth. Twenty-three children with ASD and 12 TD children wore the Actigraph GT9X accelerometer over seven days and nights to assess activity and sleep. Youth with ASD had significantly greater levels of sedentary behavior ($p=.02$), and had less sleep efficiency compared to TD youth ($p=.0001$). Additionally, TD youth were more likely to achieve the recommended levels of PA compared to youth with ASD ($p=.003$). Results suggest that youth with ASD have poorer health habits compared to TD youth. Interventions should be developed to target health behaviors in youth with ASD.

Dedications

To my parents, Dana and Deborah Barnes, thank you for always believing in me; reminding me I could do whatever I set my mind to. The two of you always taught me to be a lover of knowledge and I could never adequately thank you for it. I love you both.

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Chapter One: Introduction

Autism Spectrum Disorder (ASD) is a developmental disability characterized by various social, emotional, behavioral, and intellectual deficits (Bremer, Crozier, & Lloyd, 2016). According to the Center for Disease Control and Prevention (CDC), approximately 1 in 59 children in the United States are diagnosed with ASD each year, compared to 1 in 2000 in the 1980's. This increase in prevalence has made ASD the second most often diagnosed developmental disability in the United States (CDC, 2014).

According to the CDC, children should participate in moderate-to-vigorous physical activity (MVPA) for at least 60 minutes per day (CDC, 2018). Despite the known benefits from participation in MVPA, only 21.6% of children ages 6-19 are currently meeting these physical activity (PA) requirements (CDC, 2018). While it appears that engaging typically developing (TD) children in regular physical activity is challenging, it may be even more difficult to engage children with ASD. Previous literature indicates that primary barriers to MVPA include motor control deficiencies (e.g. balance, flexibility, coordination), preference for strict routine (reluctance to try new activities), and difficulty with social interactions (Lang et al., 2010; Bremer et al., 2016). This is particularly concerning, as 50% of children with ASD are overweight or considered to be at risk for becoming overweight (Curtin, Bandini, Perrin, Tybor, & Must, 2005) As a result, children with ASD are more likely to develop cardiovascular disease, diabetes, hypertension, and other adverse health conditions as they enter adulthood (Lang et al, 2010).

In addition to participation in MVPA, the CDC recommends that children ages 6-18 get between 8-12 hours of sleep each night (CDC, 2017). Again, a large proportion (60-70%) of TD children do not meet these recommendations (CDC, 2017). While there is limited research on the percentage of youth with ASD that meet the recommended levels of sleep duration, reports have indicated that youth with ASD experience a greater amount of sleep disturbances compared to their TD counterparts. In fact, disrupted sleep patterns are one of the most common concurrent diagnoses in children with ASD (Cortesi, Giannotti, Ivanenko, & Johnson, 2010). While TD children may simply not dedicate enough time to sleep, children with ASD may have difficulty falling asleep and staying asleep throughout the night (Cortesi et al., 2010). Inadequate sleep duration, similar to inadequate amounts of PA, is associated with adverse health conditions such as cardiovascular disease, hypertension, diabetes, and obesity (Cappuccio, D'Elia, Strazzullo, & Miller, 2010).

As children with ASD are already at an increased risk for these conditions, it is critical to identify the percentage of youth with ASD who fall short of meeting recommended levels of these health behaviors. Although there have been several studies that have examined MVPA, sedentary behavior, and sleep duration in youth with ASD, the majority of these studies have used child or parent-reported questionnaires (Lang et al., 2010; Arim et al., 2012). Subjective assessment measures, such as parent-reported questionnaires may be problematic, however, as results suggest that such measures may be prone to bias and inaccuracy, due to factors such as social desirability (Goodlin-Jones et al., 2009).

Unfortunately, only three studies have used accelerometers to measures both MVPA and sedentary behavior in this population (Boddy et al., 2015; Tyler et al., 2014; MacDonald et al., 2011), and similarly, few studies have examined objective measures to assess sleep duration and other components of sleep (e.g. sleep efficiency, sleep disruptions). No studies to our knowledge have examined all three health measures (MVPA, sedentary behavior, components of sleep quality) using accelerometers to 1) compare health behaviors of youth with ASD to a control sample of TD children; 2) determine the percentage of youth with ASD and TD youth who meet MVPA and sleep recommendations; and 3) examine associations among MVPA, sedentary behavior, and components of sleep quality in both samples. Given the evidence of health benefits obtained from participation in MVPA and quality sleep, it is essential to determine the extent that these health behaviors are achieved in youth with ASD in order to provide recommendations for future interventions.

Chapter Two: Review of the Literature

Introduction to ASD

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder characterized by physical, social, cognitive, and behavioral development (CDC, 2015). Primary characteristics of ASD include deficits in communication, difficulties interacting with others, and rigid, repetitive movements (CDC, 2015). Furthermore, children with ASD may exhibit physical impairments, such as difficulties with balance and motor coordination (Fournier et al., 2010; CDC, 2015). As a result, children with ASD may be reluctant to participate or be involved in a range of physical and social activities that likely would likely benefit their overall development (Pan, 2008).

Prevalence Rates of ASD

Currently, ASD is diagnosed in every 1 in 59 children, which is a substantial increase from the late 1990s, when only 1 in 2000 youth were diagnosed with Autism (CDC, 2018). In terms of gender, males are four times more likely to be diagnosed with ASD compared to females (CDC 2015; Loomes, R., Hull, L., & Mandy, W. P., 2017). According to Morbidity and Mortality Weekly Report (MMWR) results also shows prevalence estimates were higher for White/ Caucasian children compared to Black/African American children. Both groups were more likely to be identified with ASD compared with Hispanic children (CDC, 2018).

Primary characteristics of ASD

As previously mentioned, the two core characteristics of ASD are impairments in communication and social interaction (Bremer et al., 2016). Other characteristics of this disorder may vary among individuals, which may include inflexible or rigid tendencies, stereotypic/repetitive behaviors (e.g. hand-flapping, rocking), chronically high levels of anxiety, hypersensitivity to sensory input (e.g. loud noises, bright lights), aggressive or self-harming action, and deficits in physical function (e.g. lack of balance and coordination) (Bremer, Crozier, & Lloyd, 2016; Miles, 2011). Again, it is critical to note that the presence and severity of these behaviors and characteristics will differ by individual, which could possibly make health interventions for this population challenging.

Health behaviors in youth with ASD

The characteristics of ASD may significantly impact activities of daily living and overall quality of life for both children with ASD and their families (Srinivasan, Pescatello, & Bhat, 2014). Additionally, these characteristics may be linked with poor health behaviors, such as low levels of moderate-to-vigorous physical activity (MVPA), sedentary behavior (SB), and sleep quality (Jones et al., 2017; Malow et al., 2016). In fact, prior studies have demonstrated that youth with ASD typically accumulate lower amounts of MVPA, spend greater time engaged in sedentary behaviors, and are more likely to experience disrupted sleep patterns compared to their typically developing (TD) peers (Sounders 2009; Jones et al., 2017; Mangerud et al., 2014). As each health behavior carries its own health risks, the following sections will focus on each health behavior individually.

Physical Activity

Physical Activity (PA) is defined as movement of the human body that requires energy expenditure (CDC, 2018). According to the CDC, it is recommended that children and adolescents engage in a minimum of 60+ minutes of moderate to vigorous physical activity (MVPA) on all or most days of the week (CDC, 2018). MVPA has been linked to numerous physical and psychosocial health benefits in both TD youth and youth with ASD (CDC, 2015). Such physical benefits include, decrease in the risk of obesity, increased aerobic capacity, improved gross motor functions, and a reduction in symptoms of anxiety and depression (CDC, 2015; Kohl, H. W. & I., 2013). Although evidence strongly suggests that MVPA is beneficial to all youth, participation in MVPA may have particular benefits for youth with ASD (Kohl, H. W. & I., 2013). Youth diagnosed with social/ emotional/ behavioral disorders, such as ASD, often have impairments in balance, motor coordination, and difficulty with communication and social interaction, are at an increased risk of obesity (Jones, et al., 2017). For these youth, participation in MVPA may be even more crucial than in TD children, given the link between PA and improved social and physical outcomes (Kohl, H. W. & I., 2013). For example, youth with ASD tend to demonstrate low amounts of self-efficacy for MVPA, however, participation in MVPA may improve self-efficacy in this population, thus further promoting ongoing participation in MVPA (Kohl, H. W. & I., 2013).

Sedentary Behavior (SB)

Sedentary behavior (SB) refers to activities that require minimal body movement, and typically involve sitting or a wide range of purposes (work, driving, screen-time) (Must et al., 2005; Zabinsky et al., 2007). In addition to being behaviorally distinct from PA, evidence in TD populations suggests that high levels of PA may not protect youth from the adverse risk factors that are associated with high levels of SB (Costigan et al., 2013). A child with ASD who accumulates high levels of sedentary behavior is 40% more likely to be obese than youth with ASD who have lower amounts of sedentary behavior (Wrights, 2015). Interestingly, the studies comparing levels of SB between TD youth and youth with ASD have been mixed (Jones et al., 2017). For example, a study by Chonchaiya et al. (2011), found that children with ASD accumulated greater amounts of screen time (4.6 vs. 2.6 hours/day) and fewer complied with the screen time recommendations of 2 hours or less per day (6% vs 44%) compared to their TD counterparts. In contrast, Dreyer Gillette et al. (2015) found that a significantly higher percentage of children with ASD (19.8%) reported to never use a computer/cell phone/hand held video games/other electronic devices compared to their TD peers (8.7%). It should be noted, however, that the majority of these studies utilized self-report or parent reported measures of SB, which are prone to error through recall bias and social desirability (Goodlin-Jones et al., 2009).

Sleep Quality

Sleep quality is made up of several indicators of sleep, including total nightly sleep duration and sleep efficiency (percentage of time asleep/total time in bed). Previous research demonstrates that sufficient sleep is associated with greater physical, mental, and social functioning in TD youth (Gregory & Sadeh, 2012). The CDC recommends that children ages 6-18 get between 8-12 hours of sleep each night (CDC, 2017). Despite the benefits of sufficient sleep, a large proportion (60-70%) of TD children did not meet these recommendations (CDC, 2017). Unfortunately, these percentages were even worse for youth with ASD with studies indicating that as many as 88% of youth with ASD may experience disrupted sleep patterns, with insomnia being the most common complaint (Cortesi, Giannotti, Ivanenko, & Johnson, 2010). Sleep quality in youth with ASD may be negatively affected by factors such as high anxiety levels and dysregulated circadian rhythm (Cortesi, Giannotti, Ivanenko, & Johnson, 2010). The US National Sleep Foundation has identified youth with ASD as one of the highest priority populations for sleep research and treatment (Mindell et al., 2006). Similar to MVPA participation, sleep disturbances in youth with ASD have been linked with poor academic performance, impaired motor skills, and greater severity of ASD-related symptoms (Cortesi Giannotti, Ivanenko, & Johnson, 2010; Souders et al., 2009).

Gaps in the Literature

Although previous research confirms that youth with ASD display lower amounts of minutes of MVPA, and poorer sleep quality compared to TD youth, several gaps in the literature have been identified. First, while there have been over a dozen of articles that have examined SB in youth with ASD, only three of these studies utilized objective measure to assess activity levels, and none of these studies compared these results with TD youth (Boddy et al., 2015; Tyler et al., 2014; MacDonald et al., 2011). Furthermore, no found studies, have compared all three health behaviors between TD youth and youth with ASD; as well as examining the relationship among these three health behaviors with both populations.

Chapter Three: Methodology:

Participants and Settings

A total of 23 youth with ASD and a comparison sample of 17 TD youth were recruited for the current study. Youth were recruited from schools located in the Central Florida area, and the Center for Autism and Related Disabilities (CARD). Investigators presented the study details to parents at a parent meeting, where interested parents could ask questions and were provided a parent consent form to sign and return.

Measures

Physical activity was assessed using the ActiGraph GT9X accelerometers (ActiGraph Inc, Pensacola FL). The ActiGraph can detect normal human motion while filtering out high-frequency vibrations that would artificially increase movement data and has been validated for use in children and adolescents in laboratory and field studies (Troiano et al., 2008). Through the use of a specialized software, ActiLife (ActiGraph, Inc.), activity counts were averaged into 1-minute epochs and validated cut-point criteria were applied to the activity counts to calculate minutes per day participants spend in moderate to vigorous physical activity (MVPA) and sedentary behavior (Evenson, Catellier, Gill, Ondrak, & McMurray, 2008). According to the algorithm developed by Evenson et al (2008), activity counts per minute that were > 2296 were classified as "MVPA", and activity counts per minute < 100 were classified as "sedentary time". MVPA was further dichotomized to indicate whether participants met the daily PA recommendations of ≥ 60 minutes.

Sleep Quality

The ActiGraph device also measured total sleep duration, defined as the average minutes of sleep per night, and sleep efficiency, which was defined as the percent of time spent asleep divided by the total time spent in bed. Similar to PA, data were run through the ActiLife software, and a validated algorithm (Cole et al., 1992) was applied to these data to calculate sleep duration and efficiency. Data was then dichotomized into whether participants met sleep recommendations (≥8 hours) and whether they were considered "efficient" sleepers (≥85%)

Data Processing and Validation Criteria

For both PA and sleep quality, any periods of 60+ minutes of "0" activity counts were designated as "non-wear time" and removed from the analysis (Trost, Rosenkranz & Dzewaltowski, 2008). Participants were required to have at least four full days of data (1 weekend day, 3 weekdays) to be included in the final analysis (Hildebrand et al., 2014; Kim & Yun, 2009). The days showing a wear-time of less than 10 hours were removed from the analysis (Hildebrand et al., 2014; Matthews, Ainsworth, Thompson, & Bassett, 2008).

Statistical analysis:

Descriptive statistics will be conducted to assess distribution patterns. Independent t-tests will be conducted to examine differences in TD youth vs youth with ASD. Chi-square tests were conducted to compare the amount of TD youth and youth with ASD who met the recommended levels of MVPA and sleep. Additionally, all quantitative statistics will be conducted with SAS 9.4 software with a significance level set at $p<0.05$.

Chapter Four: Results

Participant Characteristics

A total of 23 children with ASD and 12 TD children were included in the final analyses. Demographic information for both youth with ASD and TD is displayed in Table 1. No significant differences existed between any of the participant characteristics assessed for both groups.

Comparison of Health Behaviors between Youth with ASD and TD youth

The findings from this study indicated that youth with ASD had significantly greater minutes of SB compared to TD youth (454.2 vs. 366.5; p=0.02). Although not significantly different, a trend was observed towards TD youth accumulating a greater number of MVPA minutes per day compared to youth with ASD (127.7 vs. 97.29; p=0.08). For sleep efficiency, TD youth demonstrated significantly greater sleep efficiency compared to youth with ASD (93.53 vs. 84.31; p=0.0001), however, no significant differences existed for total sleep time between TD youth and youth with ASD (556.9 vs. 486.2; p=026).

MVPA and Sleep Recommendations

The results of the chi-square tests indicated that a significantly higher number of TD youth met recommended MVPA levels (60+ minutes of daily MVPA) compared to youth with ASD (100% vs. 52%; p=0.003) (Table 3). No significant differences in sleep recommendations were observed between TD youth and youth with ASD (58% vs. 65%; p=0.69).

Correlations between Sleep Quality and Physical Activity

For youth with ASD, a negative correlation existed between minutes of MVPA and SB (r=-.58, p=0.003), however, there were no significant relationships among either MVPA and total sleep time (r=.24, p=0.29) or efficiency (r=-.02, p=0.95). Similarly, no significant associations were found between either SB and total sleep time (r=-.001, p=0.97) or SB and sleep efficiency (r=-.19, p=0.4). For TD youth, a positive trend existed between MVPA and sleep efficiency (r=.46, p=0.1), however, there were no other associations between MVPA and total sleep time (r=.36, p=.26) or SB and both total sleep time (r=-.18, p=0.72) and sleep efficiency (r=.28, p=0.37). Additionally, there were no associations between MVPA and SB (r=-.09, p=0.79) in the TD group.

Chapter Five: Conclusion and Future Research

The purpose of this study was to compare sleep and MVPA between a sample of youth with ASD and a sample of TD youth. It was hypothesized that youth with ASD would have significantly less minutes of MVPA, total sleep time, and sleep efficiency compared to TD youth, however youth with ASD would have greater minutes of SB. Additionally, it was hypothesized that significant correlations would exist between the activity variables and sleep quality in TD youth, however those relationships would not be observed in youth with ASD. The findings provide partial support for our hypotheses in that youth with ASD spent greater amounts of time in sedentary behavior and had less efficient sleep compared to TD youth, however no differences were observed in minutes of MVPA or total sleep time between the two groups. Additionally, while the results supported our hypothesis that there would be no relationship between activity and sleep in youth with ASD, our hypothesis that activity would be correlated with sleep in the TD population was not upheld. This may be partially related to the limited sample size, however, the exact reasons cannot be determined. Future research comparing relationship between activity and sleep in both general and special populations should consider possible confounding variables, such as environmental factors (e.g. neighborhood characteristics).

The findings from the current study differ from previous literature that indicates TD youth have greater amounts of MVPA and have better sleep quality compared to youth with ASD (Must et al). Several studies have reported that youth with ASD demonstrated poorer sleep efficiency and shorter sleep duration compared to TD youth, while the current study found that only sleep efficiency was better in TD youth compared to youth with ASD (Fletcher et al., 2016; Veatch et al., 2017). It can be speculated that perhaps there are other mediating or moderating factors that could account for the contrasting findings, such as ASD severity, medication usage, or the presence of additional comorbidities (e.g. depression), that may also affect health behaviors (Elrod and Hood, 2015). In fact, a meta-analysis conducted by Elrod and Hood (2015) found that individuals with ASD and co-occurring intellectual disabilities had significantly lower sleep duration compared to individuals with ASD, but no intellectual disabilities, and TD youth. Unfortunately, the current study did not account for co-morbidities, such as intellectual disabilities, however, the majority of the sample was classified as having "higher functioning" ASD, and therefore, it is unlikely that an intellectual disability was present.

One interesting finding was the difference in accelerometer wear-time compliance in youth with ASD and TD youth. These findings are in contrast to previous research conducted by Bandini et al (2013) who found that TD children had slightly higher compliance rates than youth with ASD (81% vs 66%), however, other studies have shown that wearable devices are well-tolerated by youth with ASD, even among youth with tactile sensitivity. Hauck et al (2016) found that implementing specific strategies (e.g. incentives, parent reminders) may increase compliance with activity trackers in this population (Hauck, Ketcheson, & Ulrich, 2016). The current study emphasized the importance of wearing the devices to both the participants and their parents in ASD and TD groups. Additionally, participants were told that feedback information regarding their PA and sleep would be provided following the monitoring period, which may also have increased compliance. Interestingly, TD youth were more likely to demonstrate incompliance during the nighttime monitoring period. Although the reasons for this finding are unclear, the disproportionate rate of reported sleep disturbances among youth with ASD compared to their TD counterparts may provide insight regarding their high rate of wear time adherence during sleep periods. In other words, both participants with ASD and their parents may have been more interested in viewing their sleep report in order to better understand reasons for poor sleep. It should also be noted that the majority of previous studies utilized a waist-based placement (Leung, Siebert, & Yun, 2017), while the current study design had participants wear the device on their non-dominant wrist. While the waist-based placement may demonstrate greater accuracy compared to other placement areas, there is support from previous studies regarding the use of wrist-based protocols, with the major advantage being an increase in wear-time adherence in youth with ASD (Leung et al., 2017). The current study utilizes a wrist-based placement for both youth with ASD and TD youth, therefore controlling for any differences that could result from accelerometer placement. However, it is important for future studies to further investigate differences in wrist-based vs waist-based placement of activity trackers in youth with ASD in order to compare accuracy and adherence in this population.

Several strengths of the study should be noted. This is one of the first studies to examine the relationship among sleep, SB, and MVPA in youth with ASD in comparison with TD youth. This study also utilizes objective measures to assess health behaviors. Additionally, the investigators worked with community organizations to recruit participants, and identify youth with severe ASD-related behaviors that were ineligible to participate in the current study. Several limitations should be noted as well. The sample size was small and may lack generalizability to other populations of youth with ASD, given the high average of MVPA in this sample. Additionally, the study was a cross-sectional design, and therefore causation cannot be determined. Evidence from both TD populations, and youth with ASD has indicated that a bi-directional relationship among sleep, SB, and MVPA may exist, however, future studies are needed to identify these relationships.

The current study offers several implications for future studies. First, the results from this study indicate that interventions for youth with ASD may need to concentrate on both decreasing SB, while promoting increases in MVPA. Although the average MVPA minutes per day was high, a smaller percentage of youth with ASD met the recommended levels of activity compared to TD youth, suggesting that while a few individuals had sufficient activity levels, several participants with ASD still failed to meet the recommended activity levels. Finally, although more research is warranted, it appears that youth with ASD may have better wear-time compliance than TD youth, suggesting that the use of accelerometers to measure health behaviors in youth with ASD may be a viable option for future studies.

Overall, the results of the current study demonstrated that youth with ASD may spend more time in sedentary behaviors, are less likely to meet MVPA recommendations, and have poorer sleep efficiency compared to TD youth. Future studies should utilize a prospective approach with larger sample to better determine causal mechanisms regarding these health behaviors. Overall, it appears that youth with ASD may benefit from lifestyle interventions aimed at improving sleep, increasing MVPA, and decreasing SB.

List of Tables

Table 1 Displays participant characteristics for both Youth with ASD and TD Children.

Variables	Youth with ASD (n=23)	TD youth (n=12)	p-value
Age (yrs.)	9.99 (1.39)	10.33 (.49)	0.17
Males	15 (71%)	7 (58%)	0.44
White	13 (72%)	8 (67%)	0.75
Overweight (≥85 BMI percentile) *	9 (64%)	—	N/A
Currently taking medication**	5 (28%)	—	N/A

*out of 15 youth
**out of 18 youth

Table 2 Compares Health Behaviors between TD Youth and Youth with ASD.

Variables	Youth with ASD	TD Youth	P-value
MVPA	97.29 (51.67)	127.7 (35.26)	.08
SB	454.2 (114.9)	366.5 (72.4)	0.02
Total Sleep Time	486.2 (89.07)	556.9 (200)	0.26
Sleep Efficiency	84.31 (7.23)	93.53 (3.45)	0.0001

Table 3 Recommendations.

Variables	Youth with ASD N (%)	TD Youth N (%)	P-value
Met MVPA Recommendations	17 (52%)	12 (100%)	0.003
Met Sleep Recommendations	15 (65%)	7 (58%)	0.69

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