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Research Article

Sleep and Physical Activity in Children with Autism Spectrum: About 3 Clinical Cases

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Abstract

Sleep disturbance is common in children with autism, resulting in a great need for effective treatments. One of the proposals is based on regular physical activity. There is evidence that physical activity has a positive impact on sleep. Accordingly, the aim of the present study was to investigate the possible link between objectives measures of physical activities and sleep, obtained by altimetry in three children with autism spectrum disorders.

Three children (two boys B1 (11.1 yr), B2 (9.8yr) and one girl G1 (8yr)) were recruited. They all attended regular schools, where they all practiced physical activity for about 30 minutes a day. Two of the three children also had a sport activity outside of school. Participants were invited to wear the accelerometer monitoring (Sense Wear® Pro Armband 3, Body media) for seven consecutive days and nights. In our study, we observed three types of children with two sleep patterns, one who can be considered poor sleeper (G1 and B1; sleep efficiency <85%) and a second pattern who is a good sleeper (B2, sleep efficiency >85%). PA of these children, measured by altimetry was different for each one of them: an insufficient volume of PA (G1 sedentary girl; B1 with an important PA and B2 with a moderate PA). The dose-response effect of exercise on sleep may indicate large individual's differences but the present findings are important for to promote physical activities and prevent sedentary behaviors in children with autism.

Introduction

Autism Spectrum Disorder (ASD) is a serious neurodevelopment disorder characterized by a wide range of symptomatology, from deficits in basic skills (language, social skills; communication skills; and/or stereotyped interests/repetitive behavior) [1]. In addition to these core symptoms, impairments in motor skills in ASD are frequently observed as a limited participation to physical activities [2]. Physical Activity (PA) is integral to a child's health, fitness and well-being. Regular participation in physical activity enhances body composition, skeletal health, prepares children to lead physically active lives, improve health and contributes to the prevention or delay of chronic disease [3]. It also improves several aspects of psychological health including self-esteem and promotes social contacts and friendships. Participation in physical activity is particularly important for children with disability as it can have a positive impact on their development, quality of life and future health and life outcomes [3].

Moreover, children with ASD seem to suffer more from sleep disorders than typically developed children, with a prevalence estimated from 44 to 83% [4-7]). The most frequent impairments reported with objective measurements such as polysomnography and actigraphy were sleep onset latency, nocturnal awakenings, shorter sleep duration and lower sleep efficiency [4,6,8,9]). Then, improving the sleep quality of children is important, because sleep is vital in optimizing cognition, memory, behavioral regulation and learning [10,11]. In this context, the focus in the probably beneficial effects of PA has grown. PA not only improves the physical fitness but also reduces the maladaptive patterns of children with ASD [10]. Nevertheless, it is still difficult to understand exactly how physical exercise impacts on sleep and inversely. In particular, some association shave been found between sleep loss and exercise-induced somatic symptoms [12] suggesting physiopathological interactions between sleep and somatic symptoms. Conversely, good sleeping habits and moderate physical activity could be mutually beneficial and trigger a virtuous circle that improves fitness, particularly in sleep disorders patients [13]. Thus, measuring the sleep of children with neuro developmental disorders requires the development of tools that are easy to use, low cost, home based, noninvasive, and easily tolerated by children. Although polysomnography has been the reference examination to measure sleep patterns, children with ASD may not tolerate the PSG and the laboratory environment in which it is performed. Actigraphy, widely used in sleep research and clinical practice, is an objective and reliable method that measures sleep patterns by differentiating sleep from wake states [14] based on the detection of movement and rest.

From this study, we selected 3 cases of children with ASD who showed sleep specificities at one point in time to show the actigraphy interest in evaluating sleep disturbances. The first aim of this study was to objectively assess sleep indices in children with ASD through 7 nights of actigraphy, and to objectively quantify physical activity through 7 days consecutively. The second aim was to propose possible links between the level of PA and the sleep of these children with ASD.

Methods

Subjects

Each subject and his parents received written and oral information about the study and signed an inform consent form. This study was

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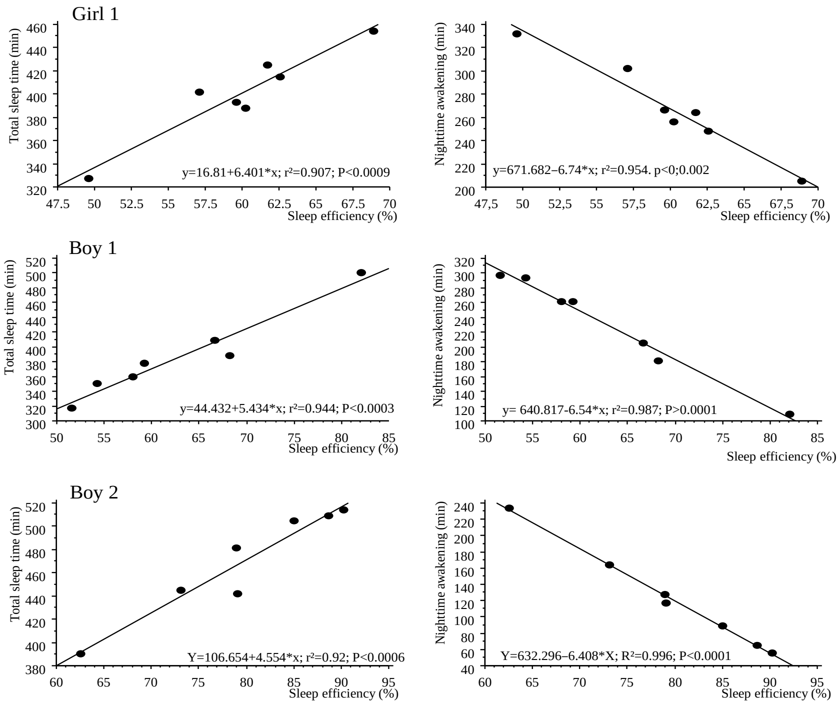

Figure 1: The relationship between sleep and PA indices in ASD.

approved by the local Ethics Committee of the Hospital (N°A00-865 40) and was conducted according to the principles expressed in the Declaration of Helsinki. The study was registered on the ClinicalTrials.gov registry.

Three children (two boys B1, B2 and one girl G1, Table 1) volunteered to participate to the study were recruited. They all attended regular schools, where they all practiced physical activity for about 30 minutes a day (playtime games or supervised sports activities). Two of the three children also had a sport activity outside of school (Table 1). Diagnosis of ASD was confirmed by experienced physicians and psychologists, according to the Diagnostic and Statistical Manual of Mental Disorders 5th edition criteria [1]. The subjects were also assessed with the Autism Diagnostic Observation Schedule (ADOS) [15]. Intellectual Quotient (IQ) was assessed using the Wechsler Intelligence Scale for Children, 4th edition [16]. The inclusion IQ criterion was children with IQ > 70 (children with intellectual disabilities (IQ < 70) were not included). In line with ethical guidelines, IQ scores and ADOS results were not available to researchers. Nevertheless, IQ scores were certified as being >70 by a clinical psychologist experienced in diagnosing children with ASD, and diagnoses of autism were confirmed for all ASD subjects included in this study. Children with co-morbid medical or psychiatric disorders, with a contraindication against physical exercise and those taking medication were not included.

Actigraphy

Participants were invited to wear the accelerometer monitoring (Sense Wear® Pro Armband 3, Body media) for seven consecutive days and nights. A daily diary was completed by participants and parents to distinguish periods when the participant did not wear the accelerometer, e.g., when bathing from genuine sedentary behavior. Such non-wear time was then excluded from the analysis.

The actigraph used in our study, (Sense Wear® Pro Armband 3, Body media) is a bi-axial accelerometer, worn on the right arm triceps. The Sense Wear Pro Armband™ incorporates a variety of measured parameters (accelerometer, heat flux, galvanic skin response, skin temperature, near-body temperature) and demographic characteristics (gender, age, height, weight) into proprietary algorithms to estimate energy expenditure. Accelerometers have previously been found to reliably measure the PA of adults with ID [17].

This device allows to measure the total sleep time(min), sleep latency (min), morning wake time (min), Wake After Sleep Onset (WASO, min) and the sleep efficiency (calculated by the actigraph as time in bed over the total sleep time, %). It was also used to calculate the time spent in sedentary, moderate, or vigorous-intensity PA (min) and to quantify the energy expenditure (K cal).

In this study, children slept in their own bedroom. The parents of the ASD cohort often described a consistent bedtime routine.

Child sleep diary

On each consecutive night for 1 week children and parents recorded three information's: (1) the time when the child went to bed (bedtime), (2) the time when the child woke up in the morning (get up time), (3) parent's estimation of the duration of the child's nighttime sleep (total sleep time).

Statistics

Data were expressed as means ± standard deviations on 7 days for each child. The coefficient of variation (CV) was calculated as the ratio of the standard deviation to the mean, and expressed as a

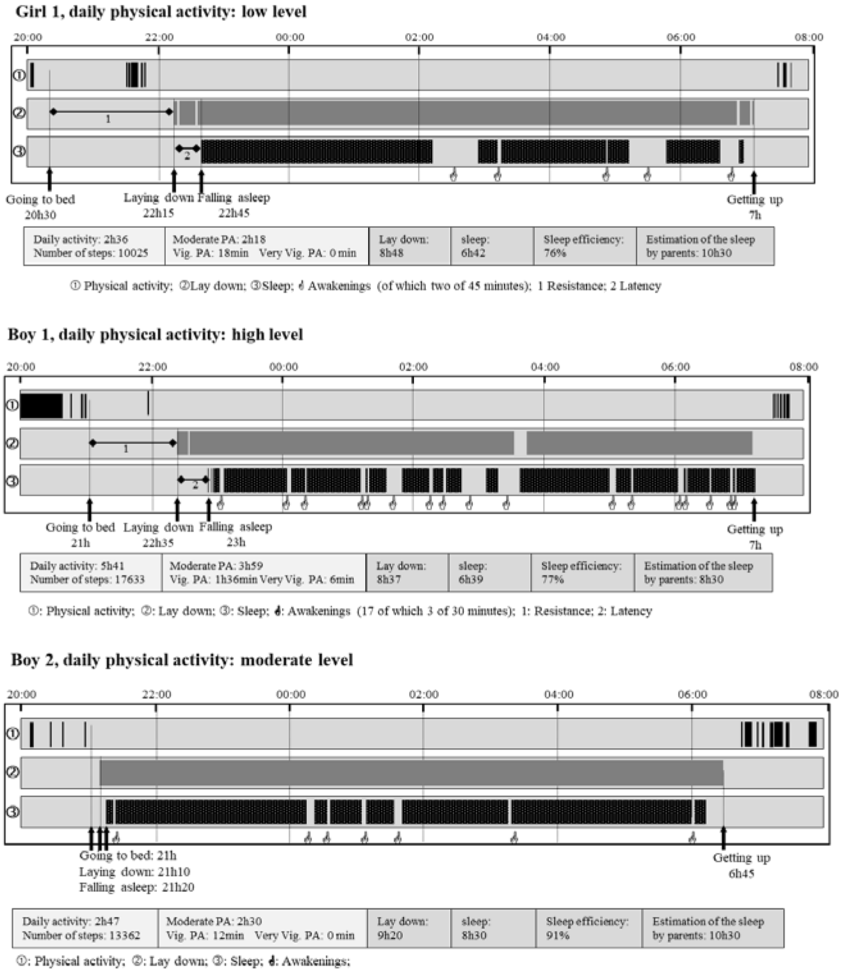

Figure 2: Example of a night recorder by actigraphy for each child.

percentage. The relationship between sleep and physical activity indices were assessed using Pearson or regression. Significance was considered when p<0.05.

Results

The characteristics of the three children are presented in (Table 1).

The main difference between the three children was the volume of physical activity practiced outside the school. G1 had no sports activity, B1 practiced an important volume of sports including one in competition (6h 30/week with four sessions per week) and B2 had a moderate practice well distributed within two sessions per week. In addition to their sports activities taking place after school there was also care support related to their ASD (psychologist ...).

Sleep characteristics

Actigraphy was well tolerated in this study. The three children contributed 7 nights and days, of actigraphy to be analyzed.

For each child sleep data varied sparsely from night to night. It was observed that B2 had better sleep quality than G1 and B1 (Table 2) confirmed with a much lower sleep latency (-130% and -110% respectively) a faster morning awakening (-77% and -33% respectively) nocturnal awakenings much less important (-104% and -65% respectively) leading to a greater sleep efficiency than the others (+ 23.6% and + 17.4% respectively). For each child the sleep efficiency is dependent on the duration of nocturnal awakenings and total sleep time (Figure 1). The relationship between sleep and PA indices in ASD was not observed.

On (Figures 2) we also could observe some interesting details that confirm the above data.

For G1, this young girl went to bed early (20h 30) but she stayed awake for 1h 45. Every night she followed the same bed ritual, playing with her dolls and toys. During this whole time, she was sitting on her bed. Then at 22h15 she finally laid down, but it took her 30 min to fall asleep. During the night she woke up 5 times, two of them being longs awakenings of 45 minutes which dropped her sleep efficiency drop. Between the estimation of the night duration by actigraphy and parents there is a difference of 4h.

For B1, this young boy went to bed at 21h but he stayed awake for 1h 35. During this whole time, he was sitting on her bed, playing with a phone or a tablet. Then at 22h 35 he was lying, but it will take him

Table 1: Characteristics of the children.

		Age	Height (cm)	Weight (Kg)	BMI	No school sports practice/week	Volume Sports/week
Girl 1	**G1**	8.0	135	27.7	15.2	No activity	0h
Boy 1	**B1**	11,1	144	31	14.9	Football/swimming	6h30
Boy 2	**B2**	9,8	138	28	14.7	Circus /swimming	2h15

BMI: Body Mass Index as body weight in kg/height in m; PA: Physical Activity

Table 2: Characteristics of the sleep.

	Girl 1	Boy 1	Boy 2
Total sleep time (min)	398.2±39.3 *(10)*	392.0±58.2 *(7)*	462.0±45.8 *(10)*
Sleep onset latency (min)	102.5±53.6 *(2)*	93.7±45.0 *(2)*	44.5±30.5 *(1)*
Morning wake time (min)	40.3±14.4 *(3)*	30.3±22.2 *(1)*	22.8±22.5 *(1)*
Nighttime awakening (min)	270.8±40.4 *(7)*	219.0±68.5 *(3)*	132.8±62.0 *(2)*
Sleepefficiency (%)	59.5±5.8 *(10)*	64.3±10.4 *(6)*	77.9±9.7*(8)*

Values are means±SD for 7 days (5 days during a classical week and 2 days during week-end). Coefficients of variation are given in parenthesis and italic.

25 min to fall asleep. During the night he was waking up 17 times, and the sleep efficiency drop dramatically. The difference between the night duration measured by actimetry and the duration estimated by his parents is 2h.

For B2, this young boy went to bed at 21h he was laying down quickly to finally fall asleep in 10 minutes. During the night he presented 6 micro-arousals of only a few minutes, which guaranteed sleep efficiency higher than the threshold of 85%, threshold value of good sleep efficiency. The difference between the night duration measured by actimetry and the duration estimated by his parents is 2h.

Physical activity characteristics

We observed that children did not change their activity between weekdays and week end for the sedentary and moderate PA time representing major activity time (Table 2). Only the coefficients of variation in vigorous and very vigorous PA duration varied for the three children being higher on school days (probably in connection with a school game or a sports activity in the school setting).

We observed that children did not change their activity between weekday and week end for the sedentary and moderate PA time that represented the majority activity time (Table 3). Only the coefficients of variation in vigorous and very vigorous PA times varied for the three children, which were higher on school days (probably in connection with a school game or a sports activity in the school setting). Each child had very different activities.

Compared to B2, G1 spent almost the same time in sedentary activities but performed less vigorous (-232%) and very vigorous (-260%) activities with a lower number of steps (-53%). B2 spent less time in sedentary activities (-46%) but performed much more vigorous activity (+ 77%) and very vigorous (+ 89%) with a very high number of steps (+ 25%), where a higher total energy expenditure (+ 20%).

Discussion

Although PA plays an important role in the development of children, very little is found about

PA behavior and the possible link with sleep in the children with

Table 3: Characteristics of the PA.

	Girl 1	Boy 1	Boy 2
Sedentary activity(min)	513.0±57.7*(23)*	397.3±101.9*(26)*	578.3±131.4*(11)*
Sedentary E.E(Kcal)	794.4±50.9*(10)*	654.4±102.2*(16)*	738.0±70.5*(6)*
Moderate activity(min)	191.8±42.7*(27)*	202.2±54.3*(27)*	217.3±57.6*(22)*
Moderate E.E(Kcal)	357.5±82.7*(28)*	399.2±100.0*(25)*	396.0±112.1*(23)*
Vigorous activity(min)	7.3±4.3*(59)*	107.5±40.0*(37)*	24.2±14.3*(59)*
Vigorous E.E(Kcal)	21.7±12.7*(63)*	378.3±142.7*(38)*	75.3±47.5*(58)*
Very Vig. activity(min)	0.5±0.8*(154)*	15.8±20.3*(128)*	1.8±2.8*(154)*
Very Vig. E.E(Kcal)	2.1±3.3*(153)*	86.0±115.9*(135)*	8.0±12.0*(154)*
Number of steps	11 627±1021*(27)*	23 683±5117*(22)*	17 799±4787*(9)*
Total E.E(Kcal)	1 175.7±79.5*(9)*	1 517.8±201.8*(13)*	1 217.1±109.7*(7)*

Values are means±SD for 7 days (5 days during a classical week and 2 days during week-end). E.E: Energy Expenditure; Vig: Vigorous. Coefficients of variation are given in parenthesis and italic.

ASD. Some studies indicate that daytime PA is associated with the quantity and quality of sleep among healthy children and adolescents [10,11,18].

In our study, we observed three types of children with two sleep patterns, one who can be considered poor sleeper (G1 and B1; sleep efficiency <85%) and a second pattern who is a good sleeper (B2, sleep efficiency >85%). PA of these children, measured by actimetry was different for each one of them: an insufficient volume of PA (G1 sedentary girl; B1 with an important PA and B2 with a moderate PA). The interest of our study is the use of the actimetry in this specific context. Actimetry provides information on the amount, frequency, and duration of PA. Data can be obtained about daytime and nighttime activity patterns and activity intensity (including estimates of energy expenditure) as they occur in children's daily lives, during consecutively 7 nights and days. In this work, we can suppose that insufficient or excessive physical activity has a negative impact on the quality and quantity of sleep. If sedentary lifestyle has often been mentioned to explain this sleep alteration [10,11,18] it is less often established that the excess of AP can be so deleterious.

Wachob and Lorenzi [19] have shown that children with ASD, increased PA was associated with increased sleep quality, and regular exercise represents an interesting non-pharmacological treatment for poor sleepers, such as her the young girl G1. Nevertheless, these authors found positive associations between daytime activity levels and sleep habits, positive associations that we did not find in our study. It is likely that this difference is induced by the types of activity practiced by the children and the practice duration. These authors concluded that further investigation was needed to better understand these links. In particular, it will be important to check what time of day these activities take place. The influence of exercise on improving sleep onset latency and decreasing Wake After Sleep Onset (WASO) was found positive when the exercise took place 4-8 h before bedtime, and negative when the exercise was performed more than 8h or less than 4h before sleep [20].

Otherwise, in our study, the observation of the young boy B1 was very interesting. This case showed that excess of physical practice was no longer necessarily beneficial to a good quality of sleep. In this sense, several European or American expert committees have defined the criteria for intensive training. These are based on the volume of training hours: more than six hours per week for prepubescent children [21,22].

Finally, it appears that it is a regular PA well dosed and distributed over the week (as for the boy B2) that is most appropriate to ensure a quality of sleep. In the context of autism, where sleep disorders are major this information can be very important. PA is a simple, inexpensive intervention, and whose benefits on the core-symptoms of ASD are significant. Nevertheless, more rigorous methodological studies need to be conducted to better demonstrate the beneficial effects of exercise training on sleep patterns

Conclusion

Even if a large consensus exists regarding the fact that daytime impact of PA is a major issue in the sleep disorders, the nature and the magnitude of this impact are still controversial. The dose-response effect of exercise on sleep may indicate large individual's differences; but the present findings are important for a better understanding of PA behavior in children with ASD aiming to promote physical activities and prevent sedentary behaviors.

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