

Social jetlag, academic achievement and cognitive performance:

Understanding gender/sex differences

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### Abstract

Adolescents in high school suffer from circadian misalignment, undersleeping on weekdays and oversleeping on weekends. Since high schools usually impose early schedules, adolescents suffer from permanent social jetlag and thus are a suitable population to study the effects of social jetlag on both academic and cognitive performance. In this study, 796 adolescents aged 12 to 16 reported information about their sleep habits, morningness-eveningness, cognitive abilities and grade point average. Time in bed on both weekdays and weekends were not related to cognitive abilities, and only time in bed on weekdays was related to academic achievement. Social jetlag was negatively related to academic achievement, cognitive abilities (except for vocabulary and verbal fluency abilities) and general cognitive ability (*g*), whereas morningness-eveningness was slightly positively related to academic achievement and marginally negatively related to inductive reasoning. Results separated by sex/gender indicated that social jetlag may be more detrimental to girls' performance, as it was negatively related to a greater number of cognitive abilities and grade point average.

Keywords: sleep habits, morningness-eveningness, cognitive abilities, academic achievement, gender/sex differences.

## Introduction

Interest in studying the association between sleep and cognitive development among adolescents in their naturalistic school context has recently increased again. This interest is derived from the results of recent studies that indicate that sleep regularity is important not only at structural and functional levels of the central nervous system but also at the behavioral level (Astill et al., 2012; Gruber et al., 2010). Although laboratory studies using experimental designs among children and adults have shown a negative effect of sleep deprivation on cognitive performance (Koslowsky & Babkoff, 1992; Lim & Dinges, 2010; Philibert, 2005; Pilcher & Huffcut, 1996), the way in which habitual sleep habits at school affect both academic and cognitive performance in adolescents and children in non-experimental conditions is still unclear (Dewald et al., 2010).

The published literature supports the importance of total sleep time for full enhancement of academic functioning. The major contributions were realized during the second part of twentieth century and these results agree with the fact that obtaining optimal sleep length is associated with better school performance (Guérin et al. 2001). More recently, systematic reviews provide ample evidence that inadequate sleep has significant consequences on key aspects of adolescent's health and functioning, including somatic and psychosocial health, emotional state, academic performance and risk-taking behavior (Beebe, 2011; Nixon et al., 2008; Schochat et al., 2013; Wilhelm et al., 2012). From classical studies, it is well-known that sleep duration is affected by multiple biological (e.g. pubertal development), social (e.g. housing conditions or parental income) and psychological factors (e.g. depression or anxiety) and that the best performance at school was observed with a sleep duration longer than 600 min/night (see Poulizac, 1979 or Vermeil, 1987). In this way, it is considered that the consistent

mismatch between morning school schedules and evening preference of adolescents, influences their academic and cognitive performance (Touitou, 2013).

Lack of sleep during adolescence is an epidemic that has been progressively increasing from decade to decade (Gradisar et al., 2011). This situation is dramatic among Chinese, Korean, Japanese and Asian adolescents, who generally have later bedtimes than those from Europe and North America (Mak et al., 2012; Rhie & Chae, 2011). Adolescent's sleep delay is relatively long compared to children's and adults', leading to shorter time in bed during the week due to the early start time of school. Although high school begins early in the morning compared to elementary school and this change toward earlier start times during adolescence is not universal (Koscec et al., 2014), this misalignment between biological (evening preference) and social (early school time) time is very common among adolescents, who tend to be much later chronotypes than other age groups (Roenneberg et al., 2004). This mismatch between internal and external rhythms has been considered as a risk factor for low academic performance and poor health (Wittmann et al., 2006), and despite the fact that the effects of sleep deprivation have been extensively studied, there are not many studies which consider the effects of interindividual variables such as morningness-eveningness.

Beyond the well-known pernicious effects of sleep deprivation on psychological functioning derived from experimental designs, previous research suggests the need to analyze how different aspects of cognition are affected by inadequate sleep in children and adolescents who attend school every day (Gruber et al., 2010). The present study aimed to fill this gap in knowledge by identifying how different aspects of the sleep habits, such as sleep length (time in bed), sleep irregularity (considered as the difference between time in bed on weekdays and weekend), and circadian preference

(morningness-eveningness), are related to both academic performance and cognitive functioning at school.

### *Sleep and academic performance*

In general, poor academic performance has been correlated with shorter sleep times, irregular sleep schedules, later bedtimes and increased daytime sleepiness in both children and adolescents (Carskadon, 2002). Additionally, specific sleep characteristics, such as shorter sleep length and irregularity in waking and sleeping times, have been related to later developmental outcomes (Curcio et al., 2006). For example, sleep disturbances at 16 years of age predict sleep disturbances in adulthood (Dregan & Armstrong, 2010). However, although the relationship between sleep length and academic performance has been meta-analyzed (Dewald et al., 2010), some studies have not found associations between sleep quantity or quality and academic achievement (Eliasson et al., 2002).

The effects of sleep on academic functioning appears even during the childhood (Becker, 2014), nevertheless, it is well-documented that as children mature, the sleep-wake rhythm becomes more irregular and delayed due to later sleep onset and wake times. During the second decade of life, adolescent bedtime is progressively delayed both on weekdays and weekends. Furthermore, morning wake time is later on weekends and earlier on weekdays (due to school attendance), resulting in a sleep debt during the weekdays. This gradual decrease in sleep time is linked to a progressively delayed bedtime, resulting in a displacement of adolescent circadian preference for an evening chronotype (Díaz-Morales & Randler, 2008; Tonetti et al., 2008). The shift to eveningness is earlier in girls, coinciding with earlier pubertal development. Some studies have indicated sex differences in eveningness at this critical period (Caci et al., 2005; Díaz-Morales & Gutiérrez, 2008; Gaina et al., 2006).

More importantly, due to early school starting times, evening adolescents experience a greater misalignment between biological and social rhythms; they sleep less on school days and report more oversleeping during the weekends (Collado et al., 2012; Digdon, 2010; Tzischinsky & Shochat, 2011). Because this type of shift is comparable to jetlag, it has been described as social jetlag (SJL). SJL has important consequences for health because, in contrast to jetlag, which is transitory, SJL is permanent (Touitou, 2013; Wittmann et al., 2006). High SJL refers to a pattern that implies a drastic variability between a person's weekday and weekend sleeping schedules, which is more prevalent among evening adolescents. Thus, this stage of life is especially suited to examine the relationship between SJL and academic and cognitive performance. SJL has been related to depression (Levandovski et al., 2011), higher body mass index (Roenneberg et al., 2012), higher frequency of cigarette smoking (Wittmann et al., 2006), higher heart rate and cardiovascular risk (Kantermann et al., 2013), and worse academic performance among undergraduates (Haraszti et al., 2014). However, few studies have analyzed the relationship between SJL and academic performance in the naturalistic context of school, where adolescents are constrained by strict and fixed morning schedules (Touitou, 2013).

#### *Sleep and cognitive performance*

Regarding the relationship between sleep and cognitive performance, it is well known that under chronic partial sleep deprivation, neurocognitive deficits can be accumulated over time, with important consequences for later development (Diekelmann, 2014). Among children and adolescents, epidemiological surveys have highlighted the negative consequences of chronic sleep deprivation on children's cognitive abilities (Nixon et al., 2008; Touchette et al., 2007). Shorter sleep length has been related to worse executive functioning (Sadeh et al., 2002) and lower intelligence

(Busby & Pivik, 1983). However, some studies have indicated that shorter time in bed is related to higher scores on cognitive tests, which is predicted by the efficiency neural hypothesis (Haier et al., 1988) as well as classical results obtained from old studies (Terman & Hocking, 1913).

Interestingly, previous research has indicated that certain cognitive subdomains seem differentially affected by sleep loss in children compared to adults. Two recent meta-analyses summarized the negative consequences of sleep deprivation on cognitive domains. Lim and Dinges (2010) aggregated studies of adults addressing the consequences of total sleep deprivation on several cognitive domains and revealed considerable performance deficits in simple attention, moderate deficits in complex attention and working memory, and small detriments in short-term memory, whereas measures of mental processing speed and crystallized intelligence remained intact. Astill et al. (2012) summarized studies of sleep, cognition, and behavioral problems in healthy school-aged children between 5 and 12 years old showing that shorter sleep is associated with worse cognitive functioning and more behavioral problems.

Numerous studies have confirmed a synchrony effect with better performance at times that match individuals' preferences (i.e., the morning versus the afternoon) (Goldstein et al., 2007; Hasher et al., 2005). Morning schedules are not the optimal time of day to perform at school, especially for extreme evening adolescents. Children's (10-12 years old) performance was worse in the early morning (Van der Heijden et al., 2010), and adolescents had worse cognitive performance on attention tests during morning school (Vollmer et al., 2013). Also, two independent studies performed at schools showed a significant improvement throughout the school day (from approximately 8:30 to 14:30) in attention tests (Clarisse et al., 2010; Escribano & Díaz-Morales, 2014).

*Relations between social jetlag, academic achievement and cognitive performance*

Because academic achievement outcomes provide only a limited view of the spectrum of cognition, the relationship between sleep and cognitive functioning may differ from the relationship between sleep and academic performance (Hunt & Jaeggi, 2014). Multiple cognitive and non-cognitive factors are implicated in academic performance, such as motivation, personality traits and thinking styles (Roeser et al., 2013). Moreover, moderator variables, such as sex and gender, may affect the relationship of sleep to both cognition and academic performance. Apart from sex differences in developmental timing, gender roles may influence the relationship between sleep and both cognition and academic performance; girls' achievement goals are related to increasing their competence and advancing in their studies, whereas boys' achievement goals are related to obtaining approval or avoiding rejection by parents (Inglés et al., 2011). Most studies have failed to report separate outcomes for boys and girls, leaving possible sex and gender differences within the pool of unexplained variance (Astill et al., 2012).

The aim of this study was to analyze associations between sleep habits and both academic achievement and cognitive performance among healthy and non-sleep-deprived adolescents in the naturalistic context of school. Given previous results about the relationship between sleep length, academic achievement and cognitive performance, it is predicted that sleep duration will be positively related to academic achievement and cognitive performance. A critical point to consider in the study of cognitive performance at school is not only sleep duration but also the regularity in wake times and bedtimes of adolescents during the school week and weekend. Because SJL is a relatively new construct, this study takes a closer look at the associations between SJL and both academic achievement and cognitive functioning. It is

hypothesized that high SJL will be negatively related to both academic and cognitive performance. Finally, this relationship is explored for both girls and boys because of the sex differences in developmental timing during adolescence.

## Methods

### Participants

Participants in this study included 796 adolescents aged 12 to 16 ( $M = 14.1$ ,  $SD = 1.48$ ). Of this sample, 53.3% (425) were girls. The age distribution by sex was as follows (total: girls and boys): 12 (128: 69 and 59), 13 (162: 84 and 78), 14 (170: 84 and 86), 15 (181: 103 and 78) and 16 (155: 85 and 70). All adolescents were studying Compulsory Secondary Education in three public schools in an urban area located in the east of Madrid (Spain), which comprises several cities with populations of more than 100,000 people. Approximately 35% of the active population works in the industrial sector. The most commonly represented socioeconomic status in this study was middle class. The board of directors authorized the study after obtaining parents' permission. Participation was voluntary, unpaid and anonymous. Ethical commission of Faculty of Psychology approved the study which was conducted in accordance with the ethical standards of *Chronobiology International* (Portaluppi et al., 2010).

### Variables and instruments

*Sleep habits: time in bed and social jetlag.* Questions about sleep habits were asked using the *School Sleep Habits Survey* (Wolfson et al., 2003). The questionnaire consists of simple, open questions about typical bedtime and rising time during weekdays and weekends. *Time in bed* was assessed by asking the following questions: What time do you usually go to bed on weekdays/weekends? What time do you usually wake up on weekdays/weekends? From these questions, time in bed during weekdays and weekends was estimated. A proxy to *social jetlag* was calculated according to the

formula indicated by Wittmann et al. (2006) considering the absolute difference between mid-sleep on weekdays (MSW) and mid-sleep on weekends (MSF):  $\Delta MS = |MSF - MSW|$ . First, to calculate mid-sleep, the middle points of time in bed on weekends and weekdays were calculated. Then, mid-sleep for both weekends and weekdays was calculated: bedtime + the middle of sleep length for both weekends and weekdays. The middle point of time in bed (the midpoint between bedtime and rising time), which is a proxy for mid-sleep (the midpoint between sleep onset and waking), was used (Roenneberg et al., 2003).

*Morningness-Eveningness.* The *Morningness-Eveningness Scale for Children* (MES-C) was used. This scale is an adaptation of the Composite Scale of Morningness (Smith et al., 1989) for the adolescent population (Carskadon et al., 1993). The scale has 10 items presented in language that is comprehensible for children and adolescents and includes a response scale with four or five response options for each item (Díaz-Morales et al., 2007). Scores range from 10 (eveningness) to 43 (morningness). Previous studies have reported good internal consistency, with Cronbach's alphas from 0.70 to 0.82 in American, Australian, Croatian, Dutch, Hong Kong-Chinese, Israeli, Italian, Spanish, Taiwanese and Turkish adolescent samples, good test-retest reliability ( $r = 0.80$  to  $0.83$ ) and external validity using various behavioral outcomes in adolescents (Tonetti et al., 2015). In the present study, internal consistency (Cronbach' alpha) was  $\alpha = 0.70$ .

*Primary Mental Abilities (PMA).* The cognitive test administered was the Spanish adaptation of Thurstone's PMA (TEA, 1989). The PMA test battery consists of five subtests designed to cover the relatively independent factors listed below. For the verbal (V) subtest, the ability to understand ideas expressed in words, the task requires verbal recognition via a multiple-choice format. The test contains 50 items whose difficulty order increases and must be solved in a time limit of 4 minutes. The spatial

(S) subtest, the ability to think about objects in two or three dimensions, includes 20 items with a time limit of 5 minutes. The numerical (N) subtest examines the ability to work with figures and to handle simple quantitative problems rapidly and accurately. 70 items are given in a time limit of 6 minutes. Reasoning (R) involves the solution of logical problems (foreseeing and planning) and it is often identified as inductive reasoning. For this subtest, letters form a series based on a rule, and the goal is to discover the rule and mark the letter that should come next in the series. There are 30 items to be solved in a time limit of 6 minutes. Finally, Verbal Fluency (VF) is concerned with verbal recall involved in writing and talking easily. The measurement task requires the person to write as many words as possible beginning with one specific letter (as a rule, “S”) during a 5-minute period. The score on the unique principal component after exploratory factorial analysis using the V, S, N, R, and VF scores was used as an overall indicator of general cognitive ability, or *g* (Jensen, 1998). This component accounted for 48.45% of the total variance. The PMA has demonstrated adequate reliability: test-retest coefficients of 0.73 for S and VF and internal consistence (split-half) of 0.91 for V, 0.92 for R, and 0.99 for N (TEA, 1989). In the present study the internal consistence (Cronbach' alpha) was 0.97 for V, 0.95 for E, 0.92 for N, and 0.86 for R. Regarding validity, previous research found that general mental ability is one of the best predictors of academic achievement (Gottfredson, 2002).

*Academic Achievement.* The official *Grade Point Average* (GPA) in common subjects for all grade levels, such as Spanish language, mathematics, English language and social sciences, was used. The board of directors authorized the use of official grades, which ranged from 0 (worst) to 10 (best).

Procedure and data analysis

The questionnaires were completed during the usual school schedule (approximately 8:30–15:00 h) in groups of approximately 25–30 adolescents in a counterbalanced order. The assessment session lasted approximately 50 minutes and was carried out in November in order to control possible seasonal effects. Parents and school supervisors were informed about the nature and purpose of the study, and written consent to participate was requested. Multidimensional Analysis of Variance (MANOVA) was used to test age and sex effects on sleep habits (time in bed on weekends and weekdays; SJL), Morningness-Eveningness (M-E), GPA, PMA (V, S, N, R and VF abilities) and *g*. Partial Pearson correlation (controlling for age) to test the relationship among variables was calculated. A multivariate linear regression analysis for academic achievement and cognitive performance was performed separately by sex using age, sleep habits and M-E as predictors. The Statistical Program for the Social Sciences was used (SPSS Inc, 1988).

## Results

A MANOVA was performed to examine age (12, 13, 14, 15 and 16 years old) and sex effects on time in bed on both weekends and weekdays, SJL, M-E and GPA (see table 1). Time in bed on weekends and SJL increased with age ( $F_{(4,786)} = 5.71, p < 0.001, \eta^2 = 0.028$  and  $F_{(4,783)} = 8.44, p < 0.001, \eta^2 = 0.041$ , respectively), whereas time in bed on weekdays, M-E and GPA decreased ( $F_{(4,786)} = 21.41, p < 0.001, \eta^2 = 0.098$ ;  $F_{(4,786)} = 7.01, p < 0.001, \eta^2 = 0.034$ ; and  $F_{(4,786)} = 10.94, p < 0.001, \eta^2 = 0.053$ , respectively). Girls reported higher time in bed on weekends, SJL and GPA ( $F_{(1,786)} = 22.54, p < 0.001, \eta^2 = 0.028$ ;  $F_{(1,786)} = 36.48, p < 0.001, \eta^2 = 0.044$ ;  $F_{(1,786)} = 5.68, p < 0.05, \eta^2 = 0.007$ , respectively). Boys reported higher mean scores on M-E, although this difference did not reach statistical significance ( $F_{(1,786)} = 2.96, p < 0.08$ ). All age by sex interactions were no significant. Also, Partial Pearson correlation coefficients

(controlling for age) among general cognitive ability ( $g$ ), abilities and GPA indicate similar significant relationships ( $p < 0.001$ ) by sex (girls and boys) in  $g$  ( $r_s = 0.40$  and  $0.44$ ), Vocabulary ( $r_s = 0.36$  and  $0.33$ ), Spatial ( $r_s = 0.18$  and  $0.21$ ), Inductive Reasoning ( $r_s = 0.37$  and  $0.33$ ), Numerical ( $r_s = 0.19$  and  $0.29$ ) and Verbal Fluency ( $r_s = 0.23$  and  $0.32$ ) abilities.

Insert Table 1 here

To test age and sex effects on PMA and  $g$ , a second MANOVA was performed. Statistical values are indicated in Table 2.

Insert Table 2 here

Higher scores were obtained for PMA and  $g$  with increasing age. Boys obtained higher scores on Spatial and Numerical abilities. The age by sex interaction effect was significant for Vocabulary: girls scored higher at 13 and 14 years of age, whereas boys scored higher at 12, 15 and 16 years of age.

Partial Pearson correlation coefficients (controlling for age) among time in bed on both weekends and weekdays, SJL, PMA,  $g$ , GPA, sex (girls coded as 0 and boys, as 1) and M-E were calculated (see Table 3). Time in bed on weekends was positively related to time-in-bed on weekdays and SJL and negatively related to sex (indicating that girls reported longer time in bed during the weekend) and M-E. Time in bed on weekdays was negatively related to SJL but positively related to GPA and M-E. SJL was negatively related to PMA (except for Verbal Fluency),  $g$ , GPA, sex (girls reported longer SJL), and M-E. General cognitive ability ( $g$ ) was strongly correlated to all of these factors in the following order: R, V, VF, S and N; and was negatively related to SJL, whereas GPA was positively related to PMA,  $g$  and time in bed on weekdays. Finally, M-E was marginally negatively related to R and positively related to GPA.

Insert Table 3 here

To analyze the contribution of age, SJL, time in bed on weekend, time in bed on weekdays, and M-E on PMA (specific abilities),  $g$  and GPA, seven multiple regression analyses were performed. In view of significant sex differences shown previously on S, N and GPA, the same regression analysis was performed separately for girls and boys.

Among girls (see Table 4), PMA, and  $g$ , were positively predicted by age (except for S) and negatively predicted by SJL (except for Verbal Fluency ability). GPA was negatively predicted by age and SJL, and positively predicted by time in bed on weekdays. Finally, only M-E was negatively related to R. The percentage of variance explained ranged from  $R^2 = 0.03$  (Spatial) to  $R^2 = 0.12$  ( $g$  and GPA, respectively).

Insert Table 4 here: girls

Among boys (see Table 5), PMA, and  $g$ , were positively predicted by age, and only R and N were negatively predicted by SJL. Additionally, GPA was negatively predicted by age and positively predicted by time in bed on weekdays. M-E did not reach a significant level in the prediction of R. The percentage of variance explained ranged from  $R^2 = 0.01$  (Spatial) to  $R^2 = 0.17$  (Verbal Fluency)

Insert Table 5 here: boys

## Discussion

In this study, the relationships among sleep habits (time in bed on weekends and weekdays and social jetlag), morningness-eveningness, academic achievement and cognitive performance (specific abilities and  $g$ ) were tested together for the first time among adolescent girls and boys in the naturalistic context of high school.

Time in bed on weekdays and weekends were not related to primary mental abilities, and only time in bed on weekdays was related to academic achievement. Social jetlag was negatively related to academic achievement, primary mental abilities (except for vocabulary and verbal fluency abilities) and *g*, whereas morningness-eveningness was slightly positively related to academic achievement and marginally negatively related to inductive reasoning. When these relationships were analyzed separately by sex, in girls, SJL was negatively related to GPA and the majority of specific abilities tested here (except for VF) whereas in boys, SJL was negatively related to two specific abilities, R and N; it may indicate that negative effects of SJL on performance are greater in female sex. This study adds interesting new insights about the negative role of social jetlag in academic achievement and cognitive performance at school, especially among girls.

Bearing in mind the detrimental effects of sleepiness on academic performance for most adolescents, time in bed on weekdays decreased with age from 8:39 h (12 years old) to 7:51 h (16 years old), whereas girls reported a longer time in bed on weekends than did boys. Recent studies have reported that short sleep duration (< 9 h for adolescents) affects academic achievement, motivation and attention (Merikanto et al., 2013; Perez-Lloret, 2013; Stea et al., 2014). Results obtained in the present study indicated that time in bed on weekdays was positively related to GPA. Because sleep factors had different influence on academic achievement (showing sleepiness the strongest relation, followed by sleep quality and sleep duration) (Dewald et al., 2010), this could explain the weak relationship between time in bed on weekdays and GPA ( $r = 0.13$ ). Also, probably, in samples of adolescents with dramatic lack of night sleep duration the relation between time in bed and GPA would be large (Mak et al., 2012; Rhie & Chae, 2011).

Similar to results that were meta-analyzed by Astill et al. (2012), intelligence test scores appeared to be a consistent trait that was unaffected by variations in sleep duration. The lack of relationship between time in bed and primary mental abilities could be explained by the fact that adolescents have a more elaborate arsenal of brain mechanisms to support synaptic downscaling during sleep period than do adults, whose mechanisms may have become much more dependent on sleep (Astill et al., 2012). Moreover, subjective feeling upon awakening may have a greater effect on cognitive performance than subjective sleep quantity (van der Heijden et al., 2013). Additionally, some studies have reported a positive relationship between cognitive abilities and sleep duration (Gruber et al., 2010), whereas others have reported a negative correlation in children and adolescents between 7 and 16 years of age (Escribano & Díaz-Morales, 2014; Geiger et al., 2010; Grubar, 1985). The latter finding is supported by the neural efficiency theory (Haier et al., 1988), which suggests that “children with higher cognitive efficiency, reflected by higher scores of cognitive measures, may also display higher nighttime efficiency (i.e., more efficient neuronal recovery) reflected by shorter sleep duration” (Geiger et al., 2010, p.953). Developmental stage (i.e., children, adolescents and adults) may be implicated in these apparently contradictory results regarding the relationship between sleep duration and cognition (Gruber et al., 2013).

Social jetlag was negatively related to primary mental abilities (except for vocabulary and verbal fluency) and academic achievement, especially among girls, as it was said above. Late chronotypes, which include the majority of adolescents, show the largest difference in sleep timing between work/school and free days, delaying bedtimes approximately 2:20 h on the weekend (Gradisar et al., 2011; Wittmann, et al., 2006). The results of the present study indicated that girls delayed their bedtimes 00:25 m longer on weekends than did boys. Additionally, morningness-eveningness and

inductive reasoning were marginally negatively related, in line with previous findings about relationship between eveningness and intelligence (Díaz-Morales & Escribano, 2013; Preckel et al., 2011). However, these results add that inductive reasoning was negatively predicted by morningness-evening only in girls. These results could be related to the fact that these measures were taken in the morning (school schedule), and time of testing could act as a confounding factor which was not controlled. Whereas synchrony effects have been shown to affect fundamental executive processes among young adults, no differences were found in measures of well-established knowledge (i.e., a vocabulary test) (Hasher et al., 1999; Yoon et al., 2000). It seems that specific sub-domains of cognition (i.e., verbal abilities) are less sensitive to time of day, as previous research has indicated, and social jetlag, as results of this study show.

Social jetlag, considered here as the difference between time in bed during weekdays and weekends, seems to impact on both academic achievement and cognitive performance in adolescents more than any other sleep-wake variables, especially more than time in bed. The results obtained in this study indicate that promoting regularity at school should be considered, especially among girls, who reported higher social jetlag and tended to report higher eveningness. Complex interactions between biological and psychosocial factors are implicated in these results. It is likely that the tendency to report higher eveningness among girls is related to sex differences in developmental timing because girls have earlier pubertal development than boys do (Crowley et al., 2007; Russo et al., 2007; Thorleifsdottir et al., 2002; Yang et al., 2005). A variety of evidence indicates that delayed sleep during adolescence is a consequence of pubertal influences, and girls begin to show a delay in the timing of sleep one year earlier than boys do (Hagenauer & Lee, 2012). Carskadon et al. (1993) showed that morningness-eveningness was negatively related to the puberty stage in girls and, to a lower degree,

in boys. The shift to eveningness is earlier in girls, coinciding with earlier pubertal development, and studies have indicated sex differences at this critical period. Bedtime was delayed markedly from 6–7 years of age in both sexes, although the time windows are different among girls and boys. One study reported that girls delay their bedtime at approximately 15–19.5 years of age and boys at approximately 18–21 (Roenneberg et al., 2004), whereas another study found these ages to be 16–17 for girls and 22–24 for boys (Park et al., 2001).

Changes in the adolescent's relational and social spheres, such as school demands, new social opportunities, and less parental supervision, are implicated to some degree in this shift to eveningness (Carskadon et al., 1993; Randler et al., 2009). The well-known negative relationship between pubertal development and eveningness was mediated by family dimensions such as conflicts and autonomy, implying that these psychosocial factors are also implicated in adolescents' shift toward eveningness (Díaz-Morales et al., 2014). Adolescents may be relatively more sensitive to the circadian phase-shifting effects of evening light (Hagenauer & Lee, 2012), improving the negative effect of night screen exposition (Cain & Gradisar, 2012). Additionally, eveningness among adolescents was less severe in rural locations, where there is less exposure to artificial light at night (Vollmer et al., 2012).

Several researchers have indicated possible gender differences in reasons to wake up, suggesting that grooming routines and household chores could force girls to wake up earlier than boys on weekdays (Fredriksen et al., 2004; Giannotti et al., 2002; Yang et al., 2005). One could also speculate that boys reduce their social jetlag by keeping an earlier schedule during the weekend to participate in sport activities (Collado et al., 2012). Gender differences in daily behavioral time structure might reflect differences in social roles for both sexes (Motohashi et al., 1998). The so-called “gender

jetlag” makes reference to the consequences of the misalignment between gender roles and biological times (Díaz-Morales & Sánchez-López, 2008) and could begin to emerge during adolescence. Adolescent girls report higher social jetlag and are at risk during pubertal onset.

This study extends the results of previous research about the relationship between sleep and cognition given that few studies have directly tested the association between sleep and cognition at school. Moreover, cognition in relation to sleep in adolescents has been examined individually within separate subdomains. Although this study can be added to previous research, we considered social jetlag and morningness-eveningness as putative factors related to academic achievement and cognitive performance. The shift to eveningness during adolescence has important consequences on their psychological functioning: low school performance, higher frequency of behavioral and health risk difficulties, poor physical and mental health, and negative family relationship are imperative areas of prevention and intervention at school. Also, evening adolescents tend to obtain higher scores on intelligence test (inductive reasoning in the present and previous studies), and characterized as right-thinker, creative, intuitive, affective and inclined to cultural individualism. In consequence, “larks” and “owls” tend to follow different reasoning approaches in facing cognitive and learning tasks, which could be relevant to preventive programs at school (Díaz-Morales & Escribano, 2014).

Several limitations of this study can be indicated. Time of testing was not assessed as participants were tested during the morning school schedule and only time. Repeated measures at different times of day could be used in order to achieve more reliable measures of sleep habits, circadian preference and cognitive variables. Self-reported methodology for the assessment of sleep variables was used. Children’s own

perceptions of their sleep are useful to screen for sleep problems (Becker, 2014), however, an objective methodology, such as actigraphy, could be used in a future study to allow for reliable, continuous recording of an adolescent's sleep in their home environment. Additionally, some studies have defined sleep duration by subtracting reported wake time, whereas other studies, including this one, have based their results on time in bed. It is possible that the latter overestimates sleep duration. Also, naps taken during the week could be a relevant factor to consider in the assessment of sleep habits. Prospective studies are required in order to analyze the relative contribution of the factors considered in the present research to cognitive and academic performance. However, the results obtained in the present study indicate that early detection and treatment may be important factors to consider because the detrimental effects of curtailed or disturbed sleep in children may have more, possibly irreversible, long-term consequences than in adults.

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#### Conflict of Interest

The authors indicate no conflicts of interest.

Table 1. Means and Standard Deviations of Time in Bed During the Weekend (TBWK), Time-in-Bed During Weekdays (TBWD), Social Jet-Lag (SJL), Morningness-Eveningness (M-E) and Grade Point Average (GPA) according to age and sex.

		TBWK		TBWD		SJL		M-E		GPA		N
		M	SD	M	SD	M	SD	M	SD	M	SD	
12	Girls	10:09	01:15	08:34	00:43	02:08	00:52	26.72	4.01	6.30	1.81	69
	Boys	09:35	01:40	08:45	01:04	01:41	00:51	27.08	4.45	5.88	1.84	59
	Total	09:53	01:28	08:39	00:54	01:56	00:53	26.89	4.20	6.11	1.82	128
13	Girls	10:15	01:05	08:19	00:54	02:32	01:07	25.21	4.21	5.76	1.90	84
	Boys	10:10	01:11	08:34	00:50	02:06	00:51	26.60	4.55	5.88	1.94	78
	Total	10:12	01:08	08:26	00:52	02:20	01:01	25.88	4.42	5.82	1.92	162
14	Girls	10:34	01:03	08:06	00:49	02:28	00:45	24.81	4.06	5.70	1.88	84
	Boys	10:09	01:19	08:15	00:45	02:10	00:50	24.59	4.88	5.41	1.87	86
	Total	10:21	01:13	08:10	00:47	02:19	00:48	24.70	4.48	5.55	1.88	170
15	Girls	10:08	01:09	08:04	00:46	02:34	00:58	24.52	4.07	5.44	1.98	103
	Boys	09:36	01:21	07:53	00:53	02:10	01:02	24.79	4.52	4.81	1.92	78
	Total	09:54	01:16	07:59	00:49	02:23	01:01	24.64	4.26	5.17	1.97	181
16	Girls	10:07	01:30	07:48	00:48	02:50	01:00	24.68	4.02	5.03	1.44	85
	Boys	09:29	01:27	07:55	01:03	02:19	01:17	25.54	4.42	4.67	1.91	70
	Total	09:50	01:30	07:51	00:55	02:36	01:09	25.07	4.21	4.87	1.67	155
Total	Girls	10:14	01:13	08:09	00:50	02:31	00:58	25.11	4.12	5.61	1.85	425
	Boys	09:49	01:25	08:15	00:58	02:06	01:00	25.63	4.66	5.32	1.95	371
	Total	10:03	01:20	08:12	00:54	02:20	01:00	25.35	4.39	5.48	1.91	796

Table 2. Statistical values (F and  $\eta_p^2$ ) for sex, age and sex\*age interaction effects on Primary Mental Abilities (PMA) and General Cognitive Ability (g).

PMA	Age		Sex		Age * Sex	
	<i>F</i> (4,786)	$\eta_p^2$	<i>F</i> (1,786)	$\eta_p^2$	<i>F</i> (4,786)	$\eta_p^2$
Vocabulary	23.30***	0.10	1.45		2.63*	0.01
Spatial	5.71***	0.03	20.84***	0.02	0.85	
Reasoning Inductive	17.46***	0.08	2.24		0.57	
Numerical	8.59***	0.04	6.59*	0.01	0.79	
Verbal Fluency	24.77***	0.11	2.12		1.44	
<i>g</i>	32.67***	0.14	1.79		1.41	

Note: \*  $p < 0.05$ ; \*\*  $p < 0.01$ ; \*\*\*  $p < 0.001$

Table 3. Partial Pearson Correlation Coefficients (controlling by age) between Time in Bed During the Weekend (TBWK), Time in Bed During Weekdays (TBWD), Social Jet-Lag (SJL), Vocabulary (V), Spatial Rotation (S), Inductive Reasoning (R), Numerical (N), Verbal Fluency (VF), General Cognitive Ability (g), Grade Point Average (GPA), Sex, and Morningness-Eveningness (M-E).

	TBWK	TBWD	SJL	V	S	R	N	F	g	GPA	Sex
TBWD	.16***	-									
SJL	.22***	-.10***	-								
V	-.01	-.00	-.06	-							
S	-.01	-.02	-.07*	.32***	-						
R	.02	-.01	-.08*	.47***	.41***	-					
N	.02	-.02	-.11***	.23***	.17***	.33***	-				
VF	.00	-.04	-.03	.36***	.19***	.35***	.25***	-			
g	.01	-.02	-.11***	.73***	.62***	.79***	.56***	.63***	-		
GPA	.04	.13***	-.14***	.34***	.19***	.31***	.27***	.25***	.41***	-	
Sex	-.16***	.05	-.21***	.04	.16***	-.06	.10**	-.06	.04	-.08*	-
M-E	-.17***	.24***	-.32***	-.02	-.01	-.07+	.00	.02	-.02	.09*	.05

Note: \*  $p < 0.05$ ; \*\*  $p < 0.01$ ; \*\*\*  $p < 0.001$ ; +  $p < 0.08$ ; N = 796; Sex: 0 girls, 1 boys

Table 4. Seven multivariate lineal regression analyses ( $\beta$  and  $R^2$ ) for girls with Primary Mental Abilities (PMA), General Cognitive Ability ( $g$ ), and Grade Point Average (GPA) as criteria, and Age, Social Jet-Lag, Time in Bed During Weekdays, Time in Bed During the Weekend and Morningness-Eveningness as predictors.

	V	S	R	N	VF	$g$	GPA
Age	.25**	.13	.23***	.16*	.26***	.30***	-.10*
Social Jet-Lag	-.16***	-.10*	-.13*	-.10*	-.08	-.17***	-.26***
Time-in-Bed Weekdays	-.02	-.06	-.01	-.08	-.06	-.06	.10*
Time-in-Bed Weekend	-.05	.07	.00	.05	-.05	.00	.04
Morningness-Eveningness	-.07	-.04	-.10*	.00	.03	-.06	.00
$R^2$	.088	.035	.071	.046	.086	.122	.120

Note: \*  $p < 0.05$ ; \*\*  $p < 0.01$ ; \*\*\*  $p < 0.001$ ;  $n = 425$  girls; V, Vocabulary; S, Spatial Rotation; R, Inductive Reasoning; N, Numerical; VF, Verbal Fluency.

Table 5. Seven multivariate lineal regression analyses ( $\beta$  and  $R^2$ ) for boys with Primary Mental Abilities (PMA), General Cognitive Ability ( $g$ ), and Grade Point Average (GPA) as criteria, and Age, Social Jet-Lag, Time in Bed During Weekdays, Time in Bed During the Weekend, and Morningness-Eveningness as predictors.

	V	S	R	N	VF	$g$	GPA
Age	.34***	.10*	.26***	.20**	.40***	.38***	-.19**
Social Jet-Lag	.02	.00	-.14**	-.12*	.02	-.06	-.01
Time in Bed Weekdays	.06	-.01	.01	.00	-.03	.01	.12*
Time in Bed Weekend	.03	-.04	.06	.07	.07	.06	.00
Morningness-Eveningness	-.03	.00	-.08	-.03	.01	-.04	.06
$R^2$	.111	.014	.080	.049	.172	.145	.082

Note: \*  $p < 0.05$ ; \*\*  $p < 0.01$ ; \*\*\*  $p < 0.001$ ;  $n = 371$  boys; V, Vocabulary; S, Spatial Rotation; R, Inductive Reasoning; N, Numerical; VF, Verbal Fluency.