

# Sleep Habits and Chronotype Effects on Academic and Cognitive Performance in Spanish Adolescents: A Review

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## ABSTRACT

The increasing interest in the way in which morningness-eveningness affects psychological functioning is remarkable in recent years. Accumulating evidence demonstrates that time of day preferences and sleep habits have an influence on cognitive and school performance and adolescent's health. Our research team has been analysing the role of chronotype, sleep length and sleep irregularity in academic and cognitive performance among high school Spanish students aged 12-16. All students were tested in a naturalistic setting, at school, throughout their school day, which started in the early morning (8:00-8:30 H) and finished in the late morning/early afternoon (13:55-14:15 H). The aim of this article is to review and summarise our research examining the relationship between chronotype, sleep habits, and academic and cognitive performance among pre-adolescents and adolescents. We also analyzed the effects of morningness-eveningness on health and anxiety as they might be considered potential negative factors with an indirect effect on academic performance.

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### Keywords:

Morningness-eveningness, chronotype, sleep, academic performance, adolescence

## Introduction: Morningness-Eveningness during Adolescence

Morningness-eveningness reveals preferred times (morning *vs.* evening) for optimal feeling and performance according to individual differences in circadian phase position of biological rhythms. Morning types prefer to wake up and go to bed early and feel at their best moment in the morning (mental, physical, and social activities) whereas evening types prefer later bedtimes and rise times, become progressively more alert as the day progresses and feel at their best moment in the evening. Neither types show an intermediate position. Around 12-13 years old, a change towards eveningness has been described all around the world. Apart from biological changes (Hagenauer, Perryman, Lee & Carskadon, 2009) psychosocial factors such as family relationship (frequency of conflicts and functional autonomy) seem to be important factors explaining the progressive change towards eveningness (Díaz-Morales, Escribano, Jankowski, Vollmer & Randler, 2014). Despite the fact that there is little doubt that as children get older they progressively change their time of day preferences to later schedules (whenever they feel free to do it), discrepancies emerge regarding sex/gender-based differences. A common scale used to test morningness-eveningness in children and adolescents is the Morningness-Eveningness Scale for Children (MES-C), an adaptation of the Composite Scale for Morningness (Smith, Reilly & Midkiff, 1989) carried out by Carskadon, Vieira and Acebo (1993). This scale was used in a large sample of 5,387 Spanish pre-adolescents and adolescents (50 % girls) aged 10-16 in order to test their psychometric properties and convergent validity with self-reported sleep habits as well as to provide further evidence regarding age and sex/gender differences (Díaz-Morales, 2015). Results indicated that the highest morningness-eveningness mean difference appeared between 12 and 13 years old and girls were more evening oriented than boys. This tendency was previously found indicating that girls

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were more evening oriented than boys especially at the age of 13-14 (Collado, Díaz-Morales, Escribano, Delgado & Randler, 2012) and at the age of 16 (Randler, Vollmer, Beşoluk, Önder & Horzum, 2014). Since the change towards eveningness is supposed to be influenced by biological/hormonal changes, it could be expected that the tendency towards eveningness appears earlier in girls due to their earlier pubertal development (Díaz-Morales et al., 2014; Hagenauer et al., 2009). Regarding sleep habits, as it was expected according to the change towards eveningness, the relationship between morningness-eveningness and sleep indicated later bedtimes and rise times in evening types in comparison with morning types. This point will be discussed in depth in the next section.

Even though adolescents change towards an evening preference, school schedules are not adapted to this change and school usually starts in the early morning; what is more, high schools in Spain usually advance their starting time when students are becoming more evening oriented. This fact encouraged us to analyze the effects of morningness-eveningness on school performance in a naturalistic context, during the morning school day.

### **Sleep Habits and Sleep Irregularity during Adolescence**

Research demonstrates the influence of sleep on physical and psychological functioning, agreeing with the statement that optimal sleep time would contribute to better school performance and behavior. Adolescents usually struggle to get out of bed in the early morning and despite having to get up early in order to attend school, they usually report difficulties in going to sleep. In order to test the change towards eveningness and its relationship with changes in sleep habits, a study was carried out in which 2,649 adolescents aged 12-16 were assessed on sleep habits and chronotype (Collado et al., 2012). Students completed the Morningness-Eveningness Scale for Children (MES-C, Carskadon et al., 1993) and questions about rise time and bedtime on both weekends and weekdays adapted from the School Sleep Habits Survey (Carskadon, Seifer & Acebo, 1991). Specific questions were: *What time do you usually go to bed on weekdays/weekends? What time do you usually get up on weekdays/weekends?* From this data, sleep length (time in bed) on both weekends and weekdays was calculated. We also calculated sleep irregularity by means of calculating the difference between weekdays and weekends rise times and bedtimes (see Crowley et al., 2007; Wolfson & Carskadon, 1998). It was found a progressive delay of rising time with age on weekends but not on weekdays (presumably due to school start time) and a progressive delay of bedtime on both weekdays and weekends. Despite being more evening oriented, girls showed an earlier rise time than boys on weekdays (when school schedules might well determine rising times) but not on weekends (when students are free to choose their own schedules), showing a later rise time. Delay in both weekdays and weekends bedtimes and get up times were lower in the youngest group (12 years old) compared with the oldest one (16 years old). Our data confirm the fact that as high school students get older, they delay their sleep schedules when they feel free to do it, taking into account that during weekdays, external schedules such as school start time (which starts in the early morning) have an influence on their sleep habits. However, during weekends students are allowed to adjust their sleep habits to their time of day preferences (eveningness). Even though we did not analyze the effect of gender roles on sleep habits, we postulated they would be responsible for sex/gender-based differences found between boys and girls, taking into account that despite being more evening oriented, girls got up earlier than boys during the weekdays probably due to housework and/or grooming chores related to style their hair and make-up.

### **Morningness-Eveningness and Academic Performance**

**Morningness-eveningness, sleep habits and social jetlag.** Taking into account that adolescents become progressively more evening oriented and delay their bedtimes and rise times whenever they feel free to do it, we analyzed if morningness-eveningness and sleep habits had any impact on school performance. Later time of day preferences and bedtimes linked to early school schedules may involve difficulties in staying awake during the school day, affecting their levels of attention and concentration which are key variables in learning and performance. In this study (Escribano, Díaz-Morales, Delgado & Collado, 2012) 1133 adolescents (12-16) reported their grades in common subjects for all courses (from which Grade Point Average, GPA, was calculated) and their level of satisfaction with them. They also completed the Morningness-Eveningness Scale for Children (MES-C, Carskadon et al., 1993). Concerning the influence of sleep length on school grades, results indicated a slight but positive correlation between school performance

and total sleep time in total sample, however, when the sample was split into morning, neither and evening types, this relationship was only found in evening types who, indeed, reported less sleep time than morning and neither types. Our putative explanation considers that it is possible that those evening types who reported more time in bed were closer to the optimal sleep time. Regarding the role of morningness-eveningness in academic grades, results indicated that morningness gradually decreased until the age of 14, and then, it remained stable. According to this result, differences among chronotypes in academic performance were tested splitting the sample into two age groups: 12-14 and 15-16, controlling for sleep length due to previous results. In the youngest group, morning and neither types reported both higher grades and academic satisfaction than evening types. In the oldest group, statistically significant differences were only found between neither and evening types, without any differences between extreme groups; that is to say, neither types reported higher grades and academic satisfaction than did evening types but there were no differences between morning and evening types. In any case, in both groups, the youngest and the oldest, evening types reported lower grades and academic satisfaction. It should be considered, as it was found in a later research, that the influence of morningness-eveningness and sleep time may depend on the specific subject which is being learned. In order to prove this hypothesis, in a subsequent study, 435 adolescents who were 12-14 were tested. Participants completed the MESC (Carskadon et al., 1993) and reported their habitual sleep time and their grades in maths and Spanish language (Escribano & Díaz-Morales, 2013). It was only found a positive correlation between sleep time and maths. Furthermore, controlling for sleep length, evening types reported lower grades in maths and Spanish language, although the latter difference did not reach statistical significance.

Not only sleep length but also sleep irregularity has been demonstrated to be related to academic performance. Owing to early school start times evening adolescents experience a great misalignment between biological and social rhythms. According to previously mentioned data (Collado et al., 2012) adolescents usually report shorter sleep length during the weekdays compared with sleep reported on weekends; it seems as if they try to compensate their lack of sleep and tiredness during the weekdays by means of extending their time in bed when they feel free to do it. This fact exposes that students experience a drastic variability in their sleep habits between weekdays and weekends which can be compared with jetlag experienced because of travelling; this kind of jetlag, dubbed social jetlag, is related to health problems as well as to poor academic performance among college students (Haraszti et al., 2014; Wittmann et al., 2006). Considering self-reported habitual bedtimes and rise times on weekdays and weekends, we calculated in a sample of 796 adolescents aged 12-16 a proxy to social jetlag according to the formula pointed out by Wittmann et al. 2006. The aim was to analyze the relationship between sleep habits (time in bed on weekends and weekdays and sleep irregularity –social jetlag–), and both academic (GPA in common subjects for all grade levels obtained from school transcripts) and cognitive performance related to school grades (specific abilities were: verbal, spatial, inductive reasoning, numerical, verbal fluency and general cognitive ability - "g" factor - extracted from those specific abilities). Results indicated that time in bed on weekdays and weekends were not related to cognitive performance; only time in bed on weekdays was positively related to academic performance. Social jetlag was negatively related to academic performance, specific abilities (except for vocabulary and verbal fluency) and to g. However, when sample was split into sex, social jetlag was negatively related to academic performance and most specific abilities in girls (except for verbal fluency) whereas in boys, it was only negatively related to reasoning and numerical abilities. This data indicated that girls seem to suffer to a greater extent than boys the negative impact of sleep irregularity on performance (Díaz-Morales & Escribano, 2015).

*Self-reported vs. official grades in the relationship between chronotype and school performance.* The use of self-reported grades is a common practice in psychological research since school directors and/or parents may refuse the use of official grades. Nevertheless, self-reported grades may be affected by memory failures and/or socially desirable responses (Wolfson et al., 2003). Regarding this concern, we aimed to analyze the accuracy of self-reported grades in 1121 Spanish adolescents aged 12-16 by subtracting actual GPA (average of final grades in main common subjects) from self-reported GPA (Escribano & Díaz-Morales, 2014a). We followed up several previous researchers' recommendations: a) using the same scale for both self-reported and actual grades; b) promising confidentiality; c) asking for specific subjects and not for a general score of performance. Results indicated that a high percentage of students over-reported their grades while a substantial percentage reported their grades accurately (reported their grades within one half grade

of their actual grade). Differences between actual and self-reported grades disappeared in older students as well as in students with higher grades and the accuracy of self-reporting tended to be higher for GPA than for individual subjects considered separately. From these results it can be concluded that self-reported grades are a good estimate of actual grades, especially among adolescents who obtained higher grades and are older.

### **The Role of Intelligence**

There are several variables which, traditionally, have been considered as factors which affect school achievement, such as personality traits, motivation or intelligence. Nevertheless, in recent years, researchers are progressively discovering the effects of time of day preferences on academic performance beyond those traditional predictors (Preckel et al., 2013). The impact of time of day preferences and chronotype on academic performance might be due to the fact that evening adolescents usually sleep less; nevertheless, although the general tendency indicates that sleep length is positively related to performance, eveningness seems to have a negative impact on performance beyond its association with sleep time. It should be noted that evening types usually get lower academic grades than morning types, and this tendency persists after controlling for sleep length, as it was said above. Whereas school achievement has been positively related with morningness, some studies have indicated that evening people are more intelligent (Preckel, Lipnevich, Schneider & Roberts, 2011). For these reason, the relative contribution of morningness-eveningness in the prediction of academic performance was analyzed, after controlling for age, sex/gender, inductive reasoning and sleep length (Díaz-Morales & Escribano, 2013a). Participants were 887 adolescents aged 12–16. Academic performance was evaluated using Grade Point Average (GPA) calculated from official grades in common subjects to all courses obtained from school transcripts; inductive reasoning was measured by the reasoning subtest of Primary Mental Abilities (PMA-R, Thurstone, 1938), sleep length was calculated from rise time and bedtime questions, and morningness-eveningness was evaluated using the MESC (Carskadon et al., 1993). Inductive reasoning, age, sex/gender, sleep length and morningness-eveningness accounted for 19% variance percentage on GPA. Morningness-eveningness was a significant predictor of academic performance after controlling for traditional predictors, albeit slightly. It is worth saying that evening types got lower grades despite getting higher scores on intelligence (PMA-R). A marginal negative relation between inductive reasoning and morningness was found in a later research (Díaz-Morales & Escribano, 2015).

### **Daily Fluctuations in Attention**

There are several variables related to academic performance such as level of attention and cognitive ability which might also be affected by time of day preferences. Specific associations of sleep length with cognitive functions were found in some studies while others did not found any relationship with intelligence, sustained attention or memory (see Astrill et al., 2012). On the other hand, as it was said above, sleep regularity seems to play a role in academic performance. According to previous data, morningness was associated with higher academic satisfaction and school achievement controlling for sleep length. These results could be explained by the synchrony effect which postulates that adolescents show better performance at times which match with their time of day preferences (Hasher et al., 2012). Since high school usually starts in the early morning (around 8:00) and ends at the end of the morning/in the early afternoon (around 14:00), school schedules seem to be an advantage for morning types. Daily fluctuations in attention levels throughout the school day were tested, two different days, taking into consideration self-reported sleep length the night before testing, in a sample of 669 adolescents who were 12-16 and attended three different high schools with a different school schedule (their starting school times varied between 8:00 and 8:30 am) (Escribano & Díaz-Morales, 2014b). Instruments used were MESC (Carskadon et al., 1993), Square of Letter Test (SLT, TEA, 1997) and inductive reasoning test (PMA-R, Thurstone, 1938); students also reported their bedtime the night before testing as well as their rise time the day they were tested for attention in order to control any effects of sleep time. SLT consists of a sustained attention task comprising 90 squares formed by 16 letters distributed in four rows and four columns in which participants must point out the row or column with the repeated letter within a 3-minute time limit. Six parallel forms were used. Students completed this task three different times (when they arrived at school, in the middle of the school day and just before leaving school), two different days. General results indicated that after controlling for age, sleep length and inductive reasoning, attention levels increased throughout the school day in both

chronotypes; boys tended to reach higher attention levels than girls and, furthermore, evening type boys tended to reached higher attention levels than evening type girls. According to the synchrony effect, it was expected that morning types would benefit from an earlier start time (school which started at 8:00); in the same way, evening types could benefit from a later start time (school which started at 8:30); nevertheless, these expected trends were not found since in all high schools all chronotypes tended to get low levels of attention at the beginning of the school day. We are aware that start time differences among high schools may not be different enough to have any influence on school performance, however, it would be expected that if the difference among schools in their starting time were greater, it would result in statistically significant differences.

### **Daily Fluctuations in Mood during the School Day**

Previous research suggests an association between mood, time of day and morningness-eveningness. Nevertheless, few studies have been carried out among adolescents testing daily mood fluctuations in a naturalistic school context in order to test how chronotype and time of day are related to mood during those school hours when students are supposed to do their best. We aimed to test daily fluctuations in mood throughout the school day, two different days, checking if sleep length had any impact on these fluctuations (Díaz-Morales, Escribano & Jankowski, 2015). A sample of 655 adolescents (12-16) reported their mood levels (current level of pleasantness) three times during their school day (8:10–8:30 h, 10:20–11:40 h, 13:50–14:10 h), two different days. They also reported their morningness-eveningness preference (MESC, Carskadon et al., 1993) and time in bed the night before testing. It could be expected that morning types would register higher levels at the beginning of the school day, as it is supposed to be their optimal time of day, nevertheless, results indicated that regardless of chronotype, mood increased progressively throughout the school day and the lowest levels, in all chronotypes, were registered at the beginning of the school day, in line with results reported about daily fluctuations in attention. Moreover, morning types showed better mood compared with other chronotypes, while evening types exhibited the lowest levels of mood. Evening-type students slept less than other chronotypes, but time in bed played no role in the relationship between chronotype and mood. These results suggest that it is not shortened sleep length responsible for decreased mood in evening-oriented students. Morning and evening types' mood fluctuates throughout the school day and this fact should be taken into account by teachers when designing their methods of teaching regardless of the subject which is being taught at the beginning or at the end of the school day.

### **Thinking Styles**

Another aspect to be considered in the role of morningness-eveningness in school achievement is the way in which students prefer processing information, that is to say, the way in which they learn (Díaz-Morales, 2007; Fabbri et al., 2007). The morning types' behavior style seems to be characterized as upstanding and self-controlled, they tend to behave properly in social situations and usually show respect for external rules. On the contrary, evening types tend to be independent and non-conformists and tend to create new categories and seek new perspectives from perceptual inputs (Giamprieto & Cavallera, 2007). Left *vs.* right hemisphere preference has been considered as a type of thinking style (Stenberg, 1997). Left thinkers process the information in an analytic and sequential mode and rely on verbal-abstract representations whereas right thinkers are more intuitive, and tend to process the information in a holistic, gestalt-type synthesized and visual motor way. We aimed to investigate the relationship between circadian preference and thinking styles concerning the preference towards information processing typical of the right versus the left cerebral hemisphere among adolescents; we also considered its implication for self-reported school achievement (Díaz-Morales & Escribano, 2013b). Participants were 1134 adolescents aged 10-14 who completed the MESC (Carskadon et al., 1993), reported their level of satisfaction with their previous year grades (from 0, "poor" to 10, "excellent") and filled out the Hemisphere Preference Test (HPT, Zenhausern, 1978). HPT has been widely used in adults and it has also been demonstrated to be an accurate measure of hemisphericity among adolescents (see Díaz-Morales & Escribano, 2014). Results indicated that the percentage of left-thinkers was greater among morning types compared with evening types. Morning types and left thinkers reported the highest subjective level of achievement, followed by evening types and left thinkers, and morning types and right thinkers. Evening types and right thinkers reported the lowest subjective level of achievement. Finally, multivariate regression analysis indicated that age (being younger), left hemisphere and morning preferences accounted for 14.2% of total variance on self-reported

achievement. Those teachers who do not use different learning styles might be unaware of individual differences in thinking styles. The debate about optimal schedule at school could also take into consideration individual differences in circadian rhythms, students' and teachers' thinking styles, and type of task. An alternative to delaying school start time would be to accomplish creative and innovative teaching styles at school.

### **Motivational Aspects: Learning, Social Reinforcement and Competence Goals**

Apart from time of day preferences or sleep habits associated with sleep length and regularity, and the way in which they process the information which needs to be learned, morning and evening types also differ in personality traits (Díaz-Morales, 2007; Tsaousis, 2010). The role of motivation to learn and study and achievement goals are important factors to consider in the analysis of chronotype and academic performance (Arbabi, Vollmer, Dörfler & Randler, 2015). Considering previous research on chronotype and school achievement, we investigated chronotypes' achievement goals and in which way these tendencies had an influence on self-reported grades (Escribano & Díaz-Morales, 2015). 342 students aged 12-15 completed the MESC (Carskadon et al., 1993), reported their last year grades in common subjects for all grades of Compulsory Secondary Education, and filled out the Achievement Goal Tendency Questionnaire (AGTQ, Hayamizo & Weiner, 1991). AGTQ consists of 20 items which measure three academic goal tendencies: Learning Goals (students' interest in acquiring new knowledge and increasing their own competence); Social Reinforcement Goals (students' interest in obtaining approval and avoiding rejection from others) and Performance Goals (regarding the interest in studying in order to achieve good results and advance in their studies). We tested to what extent achievement goals had an influence on academic performance considering each chronotype separately. Results indicated that morning types reported higher Learning and Performance Goals than evening types, that is to say, they were more interested in improving their competence and obtaining good grades. Both tendencies were positively related to self-reported grades. Furthermore, achievement goals were more associated to academic performance in evening types than in morning types. This data reveals that cajoling students into advancing in their studies is especially important among evening types.

### **Morningness-Eveningness and Health**

During adolescence, students experience several physical and psychological changes and have to deal with different challenges associated with the transition from elementary to middle school. This transition to subsequent grades, which most times requires a change of school center, involves the necessity to meet new peers and dissolve their previous social networks, and usually entails more teacher-imposed discipline and less personal relationships with their teachers (Vanlede, Little & Card, 2006). For this reason, this stage of life means both developmental and social changes which may be stressful to most of students. Evening types suffer from higher levels of anxiety, obsessive-compulsiveness, hostility and phobia symptoms (Vardar, Vardar, Molla, Kaynak & Ersoz, 2008) and usually have nightmares and suffer from dream anxiety (Selvi et al., 2012). Linked to physical, psychological and social changes, evening type adolescents are forced to adapt their biological preferences to the early school schedules, consequently, morningness-eveningness may be a risk factor to consider concerning health and anxiety symptoms during this stage of life. In order to corroborate this statement, a sample of 1600 adolescents aged 12-16 completed the MESC (Carskadon et al., 1993) as well as a questionnaire developed in France (VSP-A, Simeoni, Auquier, Antoniotti, Sapin & San Marco, 2000) which measures health-related quality of life distributed in several dimensions: vitality, physical and psychological well-being, body image, relations with friends, parents and teachers, school work, leisure and relations with health professionals. It also includes subscales concerning sentimental and sexual life which were not included in the study (Delgado, Díaz-Morales, Escribano, Collado, & Randler, 2012). Results indicated that evening type adolescents got lower scores on all subscales, including the global health scale, except for relations with friends and leisure; the latter result could be due to the fact that a general trend indicates that evening types are more extraverted (Adan et al., 2012); furthermore, when they have time to spare is when they feel their best what might contribute to better social relationships. Regarding sex/gender and age, girls and older students reported worse health indicators. The negative relationship between morningness-eveningness and health was corroborated in a subsequent study. 1406 adolescents aged 12 and 16 participated in a study which tested the relationship between anxiety, sleep habits and chronotype (Díaz-Morales, 2016). Results indicated that anxiety was associated with eveningness,

early rise time and shorter sleep length (time in bed) during weekdays. Furthermore, there was a greater proportion of evening types among the high anxiety group, and girls, who suffered from higher social jetlag, reported higher anxiety levels than did boys. Eveningness, earlier rise times and shorter time in bed during weekdays were related to anxiety, whereas sleep habits reported during the weekend were not. Common affective disorders often have their onset during adolescence. Taking into account that evening types reported poor mood as well as poor health and higher anxiety, these results suggest that schools should develop educational and preventive programs focused on individual differences, considering fluctuations throughout the school day, and using different teaching methods.

### Discussion and Conclusions

The aim of this review was to describe our main findings regarding sleep habits and chronotype associated with adolescents' optimal adaptation to school environment. School achievement is influenced by multiple factors. Beyond traditionally studied variables (e.g. intelligence and other cognitive variables) other aspects such as sleep habits and time of day contribute to explain individual differences in school achievement. Our research was carried out in a naturalistic setting of school context, during an ordinary school day. A summary of results obtained is shown in Appendix 1.

The main results can be summarised as follows: a) as adolescents got older they change their time of day preferences towards later schedules; b) adolescent girls tended to be more evening oriented than boys; c) evening types reported less sleep length and greater sleep irregularity between weekdays and weekends; d) evening types got lower grades and reported less satisfaction with their academic performance; e) the negative relationship between eveningness and academic performance was found after controlling for sleep length (time in bed) and other traditional predictors related to academic performance such as sex/gender, age and intelligence; f) sleep irregularity or social jetlag (differences in sleep habits between weekdays and weekends) affected negatively academic and cognitive performance, especially among girls; g) both morning and evening types reported their lowest levels of attention and mood at the beginning of the school day in three different schools with different starting times; these levels increased progressively throughout the school day; h) evening types tended to be right thinkers; evening types and right thinkers were those who reported the lowest academic performance; i) evening types were less interesting in improving their competence and obtaining good grades than morning types, nevertheless, these goals were more related to academic performance among evening types; j) evening types reported poorer health and higher levels of anxiety; k) evening types obtained lower scores on relationships with parents and teachers but not on relationship with friends neither on leisure time.

According to these results evening types seem to be far from do their best at school. Furthermore, school schedules do not match with evening types' time of day preferences as school day ends when students are starting to feel better and get their highest levels of attention and mood, when the school day progresses. However, two aspects could be highlighted regarding evening orientation: evening types tend to be more creative and seem to be satisfied with their relationships with friends and their leisure time. Nonetheless, at schools, those subjects which involve creativity, such as Arts and Crafts or Music are being undervalued. Evening types struggle to adapt to a morning school context where their abilities are not promoted.

It seems essential to take into consideration not only specific subjects which are taught and learned at school but also the time most effective to teach and learn them. School start times force them to performance out of their preferred time of day and make them difficult to get longer sleep length. The development of different programs which promote the improvement of sleep hygiene in order to prevent from unhealthy lifestyles and their negative effects on performance is necessary. These programs have demonstrated that, certainly, students increase their knowledge about what to do to get better sleep quality and quantity, especially among evening types who usually struggle to recognise specific correct and incorrect behaviors (Díaz-Morales et al., 2012). Although the positive impact of sleep education programs on adolescents' behavior remains to be demonstrated, it seems unquestionable that adolescents, parents and teachers needs to be conscious of the way in which their sleep habits affect their daily life and performance. These programs should take into consideration individual differences regarding sex/gender and chronotype.

On the other hand, it is necessary to pay attention to the way in which different chronotypes learn. Previous studies demonstrated that adolescents tend to behave in an independent and nonconforming way and tend to resist following traditional standards, as it could be early schedules. They usually tend to be more creative, unconventional and innovative and these trends probably are not promoted at school (Ford & Chen, 2001). Conventional approaches to education usually assume that learners do not differ in processing information. Teachers who do not use different learning styles (i.e. creative and innovative tasks) may be ignoring individual differences in learning experiences. Adolescents' thinking styles may not match with teachers' methods (Zhang, 2011) leading to a double mismatch: they have to go to school out of their preferred times and prefer methods of processing information that differ from their teachers' style of teaching involving students unmotivated and bored. In order to prevent from it, teachers should have knowledge about the structure of brain and the way in which students learn. Including some techniques in teachers' handbooks could be really useful in order to deal with the educational needs of each student in any class (Felder & Silverman, 1998; Zhang, 2011). This would be an excellent way to cajole students, especially evening types, into improving their competence and advancing in their studies, favouring their school achievement.

Eveningness is related to a variety of negative factors such as worse academic performance, poorer mood, higher levels of anxiety, poorer quality of life related to health, a greater number of family conflicts, greater sleep debt and sleep irregularity. According the Social Zeitgeber Theory of mood disorders, stressful events are associated with changes in sleep/wake times that alter molecular and cellular rhythms in vulnerable individuals, leading to mood-related episodes (Ehlers, Frank & Kupfer, 1988). School programs can improve students' motivation to adopt healthy habits by means of promoting activities during the daytime, controlling light exposure during the evening and at night, and avoiding stimulant drinks before going to bed. Additionally, regular schedules and curfews imposed by parents have positive effects on adolescents' health (Gangwisch et al., 2010). Owing to the fact that common behaviors and affective disorders usually have their onset during adolescence, the study of non-clinically diagnosed individuals is essential to accomplish preventive actions.

In light of these results, delaying school start times may be an appropriate solution for both chronotypes taking into account that at the beginning of the school day morning types do not get high levels of attention nor feel happy in the early hours. On the other hand, creativity should also be promoted at school, giving greater importance to subjects which fosters creativity, such as Arts or Music. According to previous research, delaying school starting times had several positive effects on adolescents: a decrease in depressive symptoms and a slight increase in sleep length, attendance and academic performance (Owens, Belon & Moss, 2010). Despite the fact that recent studies are shedding some light on how optimize cognitive and emotional functioning in adults (Cavanough, Cutright, Luce & Bettman, 2011; Wieth & Zacks, 2012), only a few studies aimed to analyze the way in which changes in teaching styles and school schedules optimize adolescents' academic performance.

This review suggests that parents and educators should be aware of individual differences in sleep habits, time of day preferences, information processing and purposes which lead students to learn and increase their knowledge. More flexible schedules and different teaching styles would contribute to better adjustment between school and students who must deal with a plethora of developmental changes (physical, psychological and social factors) attached to this stage of life. The development of preventive programs and further research about the effects of different variables on school achievement would contribute to better understanding of school failure and negative behaviours related to healthier lifestyles.

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**Appendix 1.** Summary of aims, methods and main results obtained

Study	Aim	Sample: Participants and age	Variables/measures	Results	Contribution
M-E and academic performance.	To test differences in self-reported academic performance (GPA common subjects) and level of satisfaction according to chronotype during school day controlling for age and total sleep time.	1133, aged 12-16.	Subjective level of achievement (0, poor-10, excellent).	Sleep time only correlated with grades in ET.	Oldest group, no differences between MT and ET.
		Analysis were split into 2 age groups (12/14 and 15/16).	Mean of self-reported grades in common subjects (GPA).	Academic performance: 12/14 years old: MT, NT > ET.	Sleep time is related to performance in ET, who reported less sleep length.
			Self-reported habitual sleep time (time in bed).	Academic performance: 15/16 years old NT > ET. (controlling for age and sleep time)	ET got lower grades and were less satisfied with their grades.
M-E and academic performance in maths and Spanish language.	To test self-reported academic performance (specific subjects, maths and Spanish language) in adolescents aged 12-14, controlling for age and total sleep time.	435 adolescents, Age 12-14.	Self-reported grades (0-10) in maths and Spanish language.	Sleep time related to performance in maths.	ET reported worse performance in maths. ET also reported lower grades in Spanish language but it was not statistically significant.
		Extreme groups (MT and ET) were selected	Habitual sleep time (time in bed).	ET reported worse performance in maths, (controlling for sleep length).	
Predicting school achievement considering chronotype and other traditional predictors.	To analyze the contribution of M-E in the prediction of school achievement (GPA) after controlling for age, sex, inductive reasoning and sleep length.	887 adolescents, Age 12-16	Inductive reasoning (R).	ET scored higher in R.	R, age, sex/gender, sleep length and M-E accounted for 19 % of variance on GPA
			Sleep length (habitual rise time and bedtime).	Being younger, female sex/gender, longer sleep length, higher scores on inductive reasoning and morning preference were associated with higher school performance.	M-E accounted for an additional percentage on the prediction of school achievement after controlling for traditional predictors: Age, sex/gender, intelligence and sleep. ET and right thinkers reported the lowest level of school achievement. This study was carried out among pre-adolescents and adolescents and not among undergraduates as previous research.
			Official grades (GPA, common subjects).		
M-E, thinking styles and school achievement.	To test the relationship between circadian preferences and thinking styles (right <i>vs.</i> left hemisphere preference) and implications for self-reported school achievement.	1134 adolescents, Age 10-14.	Hemispheric Preference Test (HPT). Self-reported school achievement from "poor" to "excellent".	Greater percentage of right thinkers among ET. MT and left thinkers reported the highest level of school achievement. ET and right thinkers reported the lowest level of school achievement. Age (-), morning preference (+), right-thinking style (-), and interaction between morning preference and right-thinking accounted for 14.2 % on self-reported achievement.	

**Appendix 1 (Continue).** Summary of aims, methods and main results obtained

Study	Aim	Sample: Participants and age	Variables/measures	Results	Contribution
M-E and daily fluctuations in attention during school day.	To describe daily fluctuations in attention at three differences times of school day, two different days, controlling for sleep length and intelligence (R).	669, aged 12-16.  Three different high schools with a different schedule.	Square of Letters Test. Sleep length previous night. R.	Attention increased throughout the school day. Boys higher levels of attention. ET boys higher levels of attention than ET girls.  No differences between chronotypes.	Attention increased throughout the day in all chronotypes. Boys tended to reached on average and in the middle and at the end of the school day higher levels. ET boys tended to reach higher levels than ET girls on average and in the middle and at the end. Neither M nor ET took any advantage of the early school schedule. School with the latest start time reported the longest sleep time. At the beginning of the school day, low levels of mood in all chronotypes. It is not shortened sleep time responsible for low mood in ET.
M-E and daily fluctuations in mood during the school day.	To test daily mood fluctuations during school day, two different days checking the influence of sleep length.	655, age 12-16.	The Face Scale Time in bed the night before testing.	Regardless of chronotype, mood increased throughout the school day. MT showed higher levels than NT or ET. ET lowest levels, no caused by sleep time.	Negative role of SJL in academic and cognitive performance especially among girls (in boys only related to R and N).
M-E, social jetlag (SJL) and academic and cognitive performance.	To test the association between sleep habits (sleep irregularity), academic and cognitive performance	796, age 12-16.	Official GPA (common subjects). PMA and g. Habitual bedtime and rise time (weekdays and weekends).	SJL negatively related to academic and cognitive performance (except for V and VF) and g. SJL was more detrimental to girls.  Time in bed was not related to PMA. Time in bed on weekdays, related to academic performance.	
M-E, achievement goals and academic performance.	To test achievement goals which MT, NT and ET accomplish at school and its relationship with academic performance	342, age 12-15.	Achievement Goals Tendencies Questionnaire (AGTQ). Self-reported grades in common subjects.	MT higher Learning and Performance Goals, goals positively related to self-reported performance. Achievement goals were more associated to performance in ET.	Among ET, who scored lower in Learning and Performance Goals, academic performance tended to be more influenced by achievement goals.

Note: M-E, Morningness-Eveningness; MT, Morning Types; NT, Neither Types; ET, Evening Types; GPA, Grade Point Average; SJL, Social Jet Lag; PMA, Primary Mental Abilities; V, Verbal ability; R, Inductive Reasoning; N, Numerical ability; VF, Verbal Fluency; g, general cognitive ability; (+), positive relationship; (-) negative relationship.