A time to learn, a time to teach

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Eight years ago we had the pleasure to serve as the Directors of the Second International School on Mind, Brain and Education Basic and applied topics in biological rhythms and learning, Ettore Majorana Center for Scientific Culture Erice, Italia. The meeting was devoted to the role of sleep and circadian rhythms on teaching and learning activities. It was a very active scientific endeavor that eventually resulted in the publication of two issues of *Mind, Brain and Education*, i.e. volume 2, number 1, 2008 and volume 8 number 4, 2014.

Our knowledge of the basic mechanisms, physiology and molecular biology of sleep and circadian rhythms, including the deleterious effects of circadian disruption has significantly expanded in recent years [1]. Specific polymorphisms that affect the timing of sleep have been identified and, in addition, the idea of "social jet–lag" (i.e., the situation in which external —environmental, work and school–related— timing is separated from, and sometimes opposed to, endogenous circadian timing) has gained a significant momentum, with data suggesting this situation is a clear symptom of contemporary society [2].

Indeed, sleep is an essential process in life. It is a behavioral state defined by: (i) characteristic relaxation of posture; (ii) raised sensory thresholds; (iii) distinctive electroencephalographic (EEG) pattern; and (iv) ready reversibility [3]. Based on polysomnographic measures, sleep has been divided into categories of rapid eye movement (REM) sleep and non–REM (NREM) sleep (also called slow wave sleep). Sleep alternates between NREM and REM stages approximately every 90–120 min and these recurrent cycles of NREM and REM sleep are accompanied by major changes in physiology [3]. It can be said that we live sequentially in three different physiological states ("or bodies"): that of wakefulness, that of NREM sleep and that of REM sleep.

Since epidemiological data indicate that in our modern society we indulge about 6 h of sleep per day, the relatively longer wakefulness stage, and the relatively shorter NREM stage, have strong negative consequences for health. There is an increasing

evidence that a number of endemic pathologies like obesity, the metabolic syndrome and neurodegenerative diseases can be related to the prevalence of wakefulness in face of NREM sleep loss in contemporary, 24/7 Society [4].

Healthy adults need 7–9 hours of sleep per day and school–age children might require 10–11 hours of sleep [5]. In 2010, approximately 30 % of USA adults and 44% of shift workers reported less than 6 hours of sleep / day [6], which has been associated with fair/poor general health, frequent mental and physical distress, depressive symptoms, anxiety, and pain. Sleep insufficiency and poor sleep quality can also result from sleep disorders such as chronic insomnia, restless legs syndrome, sleep apnea, or narcolepsy.

An extreme case of sleep deprivation resulting in poor performance is found in adolescents, whose circadian clock appears to be phase–delayed and, therefore, inappropriate for the usually very early timing of high school start time of classes. Sleep in adolescents has been shown to be an important factor when looking at physical, mental and social well–being. Adolescents with short sleep duration are at an increased risk of accidental injuries [7] and a number of studies have demonstrated that sleep of insufficient duration or quality is associated with different negative mental health outcomes that include anxiety, depression, and bipolar disorders [8]. Youths who experienced sleep problems had greater odds of interpersonal dysfunction [9]. Also, late bed and rise times, erratic sleep–wake schedules, shortened total sleep time, and poor sleep quality are negatively associated with academic performance [10] [11].

Several factors affect sleep in this age group. Developmental changes due to intrinsic regulatory mechanisms in the homeostatic and circadian sleep processes delay the timing of sleep. Psychosocial issues as self–selected bedtimes, academic pressure, the use of technological resources and social networking in the evening also delay bedtime. On the other side, social pressures determine an early rise time for starting school day timely. Therefore, adolescents are asked to be awake at an inadequate circadian phase and sleep too little. Indeed, since school start time is a deterministic factor in adolescent sleep loss and disruption [12;13], a simple solution would be to slightly delay such timing. There is substantial evidence that demonstrates that delaying high school start times results in significant improvements in academic performance, reduced mood disorder–related complains and, in particular, an increased sleep time and quality [14;15].

In addition, a "sleep disparity" exists in the general population since poor sleep is strongly associated with poverty and race. A differential vulnerability to factors such as health, education and employment was suggested as mediator for this effect [16;17]. Adolescents from lower socio–economic households have poorer and less consistent sleep than those from more favored backgrounds, being the neighborhood and home conditions the aspects associated with these observations. This is aggravated by the fact that in poorer households child work is much more common, which tends to increase the risk for sleep problems since adolescents are involved in dual duties that further limit their time for sleep. According to the International Labor Organization (ILO) around 168 million children aged 5–17 years worldwide are engaged in child labor, accounting for almost 11% of the child population as a whole [18]. In Argentina, approximately 20% of teens between 13 and 17 years were involved in economical activities and 14% was involved in intensive domestic work in 2012.

In this context, less attention has been paid evidence to the sleep problems in adolescents from households facing extreme poverty conditions, where conditions like crowding, poor housing, sanitation or educational level, and a precarious employment set an adverse environment for sleep. For instance, slum dwellers report bad indexes of sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbances, daytime dysfunction that improve after minimal changes in the quality of basic housing. Understanding sleep patterns in this population could help to define interventions to reduce sleep disparity [17].

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In a recent study our research group sought to assess in a nation–wide sample comprising 1682 adolescents, how the presence of extreme poverty affects the relationship between sleep duration and school, work and other daily activities in Argentina [19]. The Unsatisfied Basic Needs (UBN) index was used as an indicator of extreme poverty. The presence of UBN was defined when children or adolescents lived in a household that presented at least one of the following: a. more than three people per room (crowding); b. house built with irregular materials or living in a rented room (housing); c. not having an indoor flush toilet (sanitation); d. having a

child between 6–12 years old who is not attending to school (school attendance); and e. households with four or more people per employed person the maximum educational level of the household head being elementary.

A global high prevalence of short sleeping time, a slight increase of sleep time in adolescents with UBN, and different patterns of wake activities that predict sleep deficit, depending on the presence of UBN, were found. The poor academic achievement, increased risk of accidents and adverse health outcomes associated with sleep deprivation support the view that sleep is an additional unsatisfied basic need that worsens living conditions at this age. The results may help to design public health policies that contribute to ameliorate this adverse situation.

In our study the presence of UBN increased rise time and sleep duration. This contradicts previous literature, where a lower socioeconomic background is usually associated with less sleep duration and more sleep disruption in adolescents. Socioeconomic demographics like income, educational level, and employment status are usually associated with more delayed, shorter duration, and less consistent sleep patterns [20]. However, none of these studies focused in situations of extreme poverty. Among the factors associated with the presence of UBN that may justify these findings, the assistance to nearby schools probably explain the increased rise time and indirectly the increased sleep time. The association between UBN and attendance to neighborhood schools is as expected, since better schools tends to be available for families with higher socio–economic status through residential mobility and enrolment in private schools. Another factor that could explain the increased rise time is the observed lower percentage of children that assist to extra–curricular intellectual or physical activities.

School starting time and full–day schooling were strong predictors of sleep deficit in adolescents with and without UBN. Starting school at the morning school is a well–recognized risk factor for sleep deprivation, determining less time spent in bed, worse sleep quality and increased daytime sleepiness which in turn leads to bad mood and poor performance. Unlike other school systems, in Argentina some schools have half–day schedules while others full–day schedules. It is expected that the extended day pose a higher risk of sleep deficit, because it combines an early school starting with being at school most of the day, thus preventing the possibility of taking naps or delaying bed time.

Child labor was a predictor of sleep deficit. In adolescents without UBN, the risk is associated with paid work, while in adolescents with UBN is associated with

intensive work at home. Our results were consistent with those of previously published studies that show that adolescents who work wake up earlier and have decreased night and total sleep duration during the week than nonworking students [21].

To conclude, in the first issue on Mind, Brain and Education devoted to the subject (volume 2, number 1) we finished our introduction by stating that "The concepts of time and timing —deeply controlled by the brain— need to be incorporated into any general view of educational processes" [22].

Six year later the prediction is still unfulfilled. This occurs in spite of the fact that chronobiology has certainly advanced our understanding of the strong influence of timing on education and academic performance, as well as for the quality of life of not only students but also teachers and parents. Indeed, the scientific study of biological rhythms and clocks can be considered part of the necessary bridge between neuroscience and education, which was originally defined as "too far" but only recently has been considered to be possible. Indeed the construction of direct links between brain data and pedagogical interventions promises to be a particularly important field of research for future neuroscience.

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