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Research Reports

Assessing the Influence of Sleep-Wake Variables on Body Mass Index (BMI) in Adolescents

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Abstract

Recent work has established an association between overweight/obesity and sleep duration, suggesting that short sleep duration and timing of sleeping may lead to overweight. Most of these studies considered sleep-length rather than any other aspects associated with the sleep and wake rhythm, e.g. chronotype, which is a measure of timing of sleeping ('when to sleep'; based on the midpoint of sleep). The objective of this study was to assess the influence of different factors of the sleep-wake cycle and of co-variates on the Body Mass Index in a cross-sectional questionnaire study. Nine hundred and thirteen pupils (406 boys, 507 girls) from Southwestern Germany participated in this study. Mean age was 13.7 ± 1.5 (*SD*) years and range was between 11 – 16 years. We found that chronotype (β = .079) and social jetlag (β = .063) showed a significant influence on Body Mass Index (BMI), while sleep duration did not. Social jetlag is the absolute difference between mid-sleep time on workdays and free days. Further, screen time (in front of TV, computer, β = .13) was positively related with BMI. Self-efficacy on nutrition (β = -.11), a psychological variable important in health-behaviour models, showed an influence with high scores on self-efficacy related to lower BMI. A high BMI was correlated with low fast-food consumption (β = -.12) suggesting that adolescents with high BMI may exert some control over their eating.

Keywords: adolescents, biological rhythms, chronotype, sleep duration, self-efficacy, screen time, overweight

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Recent work has established an association between overweight/obesity on the one side and sleep duration on the other, suggesting in general, that short sleep duration may lead to overweight (Anic, Titus-Ernstoff, Newcomb, Trentham-Dietz, & Egan, 2010; Baron, Reid, Kern, & Zee, 2011; Chaput, Brunet, & Tremblay, 2006; Chaput, Després, Bouchard, & Tremblay, 2012; Chaput & Tremblay, 2007; Eisenmann, Ekkekakis, & Holmes, 2006; Lumeng et al., 2007; Roenneberg, Allebrandt, Merrow, & Vetter, 2012; Snell, Adam, & Duncan, 2007; Taveras, Rifas-Shiman, Oken, Gunderson, & Gillman, 2008). Most of these studies considered some kind of sleep-length measure rather than any other aspects associated with the sleep and wake rhythm, such as chronotype or social jetlag (Baron et al., 2011; Roenneberg et al., 2012). Chronotype describes the timing of sleeping ('when to sleep') rather than the length of sleep. Assume, e.g. two persons both sleep eight hours, then sleep length is similar, but timing of sleeping may differ, e.g. in one person from 22:00 to 6:00 and in the other from 1:00 to 9:00. Chronotype may be measured based on clock times (see methods), and it uses the midpoint of sleep, i.e. going to be at 24:00 and getting up at 6:00 reveals a midpoint of sleep of 3:00. In addition, social jetlag describes the difference between weekdays and weekend (or free) days, based on the assumption that humans live in accordance with their biological clock when they can awake spontaneous rather than by an alarm clock (Wittmann, Dinich, Merrow, & Roenneberg, 2006). However, there is an on-going discussion about measuring chronotype by questionnaires, either by a clock-based questionnaire or by a circadian preference scale (Adan et al., 2012).

Recent studies showed that evening oriented adolescents (Fleig & Randler, 2009) and adults (Kanerva et al., 2012) showed a more unhealthy diet. In this study, we assessed the relationship between sleep-wake variables and overweight in adolescents, but in addition, we focus also on psychological and social variables (Magee, Iverson, Huang, & Caputi, 2008). More generally, there may be different mechanisms involved in the links between sleep-wake variables and BMI in childhood, adulthood and adolescence, e.g. when considering parental influence on sleep timing (Randler, Bilger, & Díaz-Morales, 2009).

There are some additional mediators or co-variates that might influence BMI, such as parental monitoring of eating behaviour, nutrition self-efficacy (Delahanty, Meigs, Hayden, Williamson, & Nathan, 2002), screen time (Li et al., 2010) and fast food consumption (Fleig & Randler, 2009). Parental monitoring has been found to a significant predictor in sleep duration (Randler et al., 2009), so we expected a similar influence on eating behaviour.

In addition to these well-known aspects self-efficacy has become an emerging topic in obesity research. Studies revealed a large body of evidence for the nutrition self-efficacy to enhance the motivation and the volition to change nutrition behaviour (Contento, Randell, & Basch, 2002; Luszczynska, Tryburcy, & Schwarzer, 2007). Self-efficacy in general mediates whether health-related actions are initiated, sustained or persisted (Schwarzer, 2008; Ziegelmann & Lippke, 2009). Different facets of healthy eating self-efficacy show strong correlations with BMI (Delahanty et al., 2002) and interventions aiming at eating self-efficacy showed effects on the BMI of the participating subjects (AbuSabha & Achterberg, 1997; Bas & Donmez, 2009; Roach et al., 2003). In this study, we focus on the relationship between sleep-wake variables and BMI, but we also take aspects of self-efficacy into account to expand previous work. We expect an influence of sleep-wake variables on BMI, but we further hypothesise that nutrition-related self-efficacy should be inversely correlated to BMI, that parental monitoring/control should be related to a lower BMI and that screen time and fast food consumption should be positively related to BMI.

Methods

Participants

Nine hundred and thirteen pupils (406 boys, 507 girls) from Southwestern Germany participated in this study. Mean age was 13.7 ± 1.5 (*SD*) years and range was between 11 – 16 years. Socioeconomic status was not measured but all participants were from middle schools ('Realschule') with parents from the middle class. Eight schools participated in the study but 44% of the data were from one single school. More than 95% of the participants were Caucasian. Participation was voluntary, unpaid and anonymous. Participants were informed prior to the questionnaire that this study was carried out to seek information about the sleep-wake cycle and different aspects of adolescents' life-habits, including nutrition. The completion of the questionnaire took between 30 and 55 minutes depending on the age of the children and was done during one regular school lesson. The study has been approved by Regierungspräsidium Stuttgart (Az74 - 6499.2/101/1). Written consent was obtained from all adolescents and from the parents.

Measurement Instruments

Sleep-Wake-Variables — Subjects were asked for rise time and bed time on weekdays and on the weekend (free days) to calculate proxies of sleep length and the midpoint of sleep on free days (adopted from Roenneberg et al., 2004). The mid-sleep time on free days (MSF) is calculated from the two questions sleep-onset time and wake time days on which there are no school or social obligations. MSF is the mid-point between these two times. The measure differs from that in (Roenneberg et al., 2004) because it uses rise times and bed times. To account for sleep debt acquired during the week, the algorithm proposed in (Roenneberg et al., 2004) was used to calculate the midpoint of sleep on free days corrected for sleep debt. The algorithm is: corrected MSF = MSF - 0.5*(SDF - (5*SDW + 2*SDF)/7) with SDF is sleep duration on free days, and SDW is sleep duration on weekdays. Additionally, average sleep duration was measured by calculating (5 * weekday sleep length + 2 * free day sleep length) / 7. ‘Social jetlag’ can be quantified by calculating the absolute difference between mid-sleep on workdays (MSW) and mid-sleep on free days (MSF) (Wittmann et al., 2006).

Body Mass Index — Weight and height were asked for to calculate Body Mass Index (BMI). To assist pupils, a ruler and a weigh were present in the classroom. Although this was based on self-report, studies showed that these self-report measures are highly reliable in adolescents but generally underestimate overweight (Brener, Mcmanus, Galuska, Lowry, & Wechsler, 2003). However, as we did not classify our subjects into categories (where the underestimation of overweight could be considerable), we used the values for correlational analysis. BMI was transformed to z-scores for each gender and age group separately to remove the effects of age and gender from the relationship.

Psychological Factors — Self-efficacy related to the nutritional behaviour (NSE) was measured with a questionnaire adopted from Lach (2003) and Schaal (2013). Within the nutrition-related self-efficacy subjects responded to five Likert-scaled items dealing with self-efficacy related to internal (e.g. ‘I am sure to eat healthy even if I have ravenous appetite for something special’) or external (e.g. ‘I am sure to eat healthy even if I am opposed to specific stressors (boredom, loneliness, too much work, conflicts, …)’) influences. Responses ranged from 1 (‘I completely disagree’) to 4 (‘I totally agree’). The scale showed an acceptable internal consistency of Cronbach’s α 0.70 in the present sample (see Schaal, 2013).

Covariates — Screen time was calculated by the mean of two items i) TV, video, DVD as one item and ii) Computer/Internet as the other item scaled from more than 4 hours daily, 3-4 hours daily, 1-2 hours/daily, 30 min daily, no min/day. Fast-food consumption was assessed based on six-point scale from 1 = almost daily to 6 = never. Parental monitoring was based on a 4-point Likert scale ‘My parents take care that I am on a healthy diet’ from 1 fully disagree to 4 = fully agree.

Statistical Analyses — All data were treated as continuous data in the calculations based on Pearson’s correlations and multiple regressions. Sleep duration, chronotype and social jetlag were inter-correlated and are calculated from the same basic data, thus two statistical approaches were used. In the first, each variable was tested singly and second, a principal component analysis (PCA) with varimax rotation was applied to create one single response variable. The factors scores from (regression) from the PCA were saved and used for further calculations. SPSS 19 was used for analyses.

Results

Descriptive statistics are presented in Table 1. Weight ranged from 27.5 kg to 90.0 kg in girls (mean ± *SD*: 52.8 ± 10.3 kg) and from 28.8 kg to 100.0 kg in boys (57.2 ± 13.2 kg). In girls, BMI was on average 19.9 ± 3.1 (range 13.0 to 32.2), and 20.1 ± 2.9 (range 14.0 to 33.8) in boys.

Table 1

Descriptive Statistics of the Sleep Variables

	Mean	***SD***
Rise time weekday	6:13	0:25
Rise time weekend	9:43	1:29
Bed time weekday	21:45	0:56
Bed time weekend	23:48	1:35
Social jetlag	2:46	1:07
Midpoint of sleep	4:15	1:18
Average sleep length	8:53	0:55
ScreenTime	2.64	0.68
Fastfood consumption	3.24	1.10
Nutrition related self-efficacy	3.16	0.75
Parental control	3.16	0.80

Less than 1% of the participants had average sleep duration below 6 hours and 2% had sleep duration below 6 hours on weekdays. 17.5% of the participants were considered as overweight (11.8% overweight, 5.7% obese). Short sleep duration, late chronotype and high social jetlag were associated with higher BMI (Table 2).

Table 2

Correlation Between Body Mass Index (BMI; z-transformed) and Sleep-Wake Variables and Co-Variates

	Body Mass Index BMI (Z-scored)
MSFsc midpoint of sleep	.095**
Social jetlag	.078*
Average sleep length	-.071*
Screen time	.118***
Fastfood consumption	-.067*
Nutrition related self-efficacy	-.111**
Parental control	-.065*

*$p < .05$. **$p < .01$. ***$p < .001$.

Social jetlag was correlated with midpoint of sleep ($r = .847$), and with average sleep duration ($r = -.246$). Midpoint of sleep was correlated with average sleep duration ($r = -.510$). All three contributed to the factor solution (principal component with varimax rotation, based on the Eigen-value > 1 criterion): midpoint of sleep loaded with .964 on the first component, sleep duration negatively with -.638, and social jetlag with .878.

The four different regression models are depicted in Table 3. In all four models, screen time, fast food consumption, and nutrition related self-efficacy had a significant influence. A high amount of screen time was related to a higher BMI. Self-efficacy was negatively related to BMI, thus, children and adolescents that were confident to retain a

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healthy diet even during adverse conditions or circumstances had a lower BMI. The extent to what parents exerted control about healthy eating was not related to BMI, but tended to be significant ($p < .1$) concerning social jetlag. Interestingly, fast food consumption was inversely related to BMI.

Table 3

Regressions of Sleep-Wake Variables, Screen Time, Fast-Food Consumption, Self-Efficacy and Parental Control on BMI (z-Scored for Age and Sex)

	Midpoint of Sleep		Social Jetlag		Sleep Duration		Factor Score	
	Beta	**Sig.**	**Beta**	**Sig.**	**Beta**	**Sig.**	**Beta**	**Sig.**
		.127		.172		.017		.032
Sleep variable	.079	.028	.063	.070	-.057	.102	.084	.020
Screen time	.138	<.001	.146	<.001	.149	<.001	.137	<.001
Fast-food consumption	-.129	<.001	-.127	<.001	-.123	<.001	-.131	<.001
Nutrition related self-efficacy	-.111	.001	-.109	.001	-.113	.001	-.112	.001
Parental control	-.050	.137	-.057	.085	-.054	.107	-.049	.148
Total model								
F	9.183	<.001	8.863	<.001	8.737	<.001	9.303	<.001
R^2	.048		.047		.046		.049	

Midpoint of sleep and social jetlag were also significant predictors, but average sleep duration was not. When composing the variables together in a single response variable, this variable also produced a significant effect.

Discussion

The results presented here add to previous knowledge about sleep duration and overweight (Anic et al., 2010; Baron et al., 2011; Chaput & Tremblay, 2007; Chaput et al., 2006; Chaput et al., 2012; Eisenmann et al., 2006; Lumeng et al., 2007; Roenneberg et al., 2012; Snell et al., 2007; Taveras et al., 2008) but suggest that chronotype and social jetlag – rather than average sleep duration – may be the more important statistical predictors of the BMI (Roenneberg et al., 2012), and thus, should be incorporated in studies dealing with overweight and obesity in adolescents. Moreover, it seems that not sleep duration alone may be the most relevant variable but chronotype as measured by the midpoint of sleep. However, the approach based on creating a single variable out of the three by a principal component analysis also showed a significant influence. Thus it may be a better solution for further studies to calculate different variables and to unify them by a statistical method. As adolescent are strongly influenced by school start times (which remain rather similar during school life), the developmental change towards late chronotype during puberty inevitably results in sleep loss according to later bed times (Dollman, Ridley, Olds, & Lowe, 2007), which may have severe consequences for obesity. Especially during adolescence, there is an abrupt change in chronotype from morning to evening types at around the age of 12-14 years (Randler, 2011) suggesting that adolescents at this age are especially high at risk.

Further, the study shows that incorporating some additional variables is important because adolescents have not the full control over their eating, and parental monitoring might be a predictor of BMI. However, perceived parental influence seems weak, which might be related to the age group of our study when adolescents become increasingly independent from their parents.

Importantly, psychological aspects – in detail the self-efficacy – have an impact on the dietary behaviour and thus on the BMI. Individuals who perceive themselves as self-efficient with respect to their dietary behaviour had a lower BMI. This stresses the importance of self-efficacy as a health-related behaviour in the relationship between sleep and overweight.

Interestingly, we found BMI inversely correlated with fast-food consumption. We suppose that individuals who are less satisfied with their weight may be more nutrition conscious in terms of not eating so much fast food. This engagement with dietary questions according to the personal self-perception would be stronger for individuals with a higher BMI than for subjects with a lower one who won't care about it. This at the first sight confusing result is in line with findings of Sabiston and Crocker (2008) who reported similar effects also in adolescents. According to them research should also focus on longitudinal designs to follow the progression of BMI and diet. But also those adolescents that are underweight may have poorer nutrition and tend towards fast foods, which could also explain the inverse relationship.

Another aspect may be the circadian timing of hormone secretion, especially of leptin and ghrelin which are responsible for energy balance. Hormones of the somatotropic and the hypothalamo-pituitary adrenal axis are involved in sleep regulation (Kluge, Schüssler, Zuber, Yassouridis, & Steiger, 2007), e.g. ghrelin administered around sleep onset increased slow-wave-sleep (Kluge et al., 2007). Also, in the morning, cortisol levels are higher in morning types than in evening given same wake and wake times (Randler & Schaal, 2010), and cortisol and ghrelin affect each other. Further, ghrelin injected in the early morning did not alter sleep but enhanced cortisol (Kluge et al., 2007). We know from melatonin that it is dependent on chronotype, i.e. late chronotypes have a later melatonin peak. Therefore, it might be possible that hormones responsible for energy balance are also time- and chronotype dependent. This could explain why evening types often skip breakfast (Meule, Roeser, Randler, & Kübler, 2012).

Biological and endocrine changes during adolescence period may affect lipid metabolism, circadian preference, nutritional behaviours and sources of interests (screen time, physical activities…). These pubertal transitions occur principally between ages 10 to 16 which were the age of our study population. Therefore, the study population may be very heterogeneous concerning age. Perhaps in the future, studies might focus on a small age range or analyse age groups separately (given high sample sizes).

Limitations

In general, this study was correlational and cross-sectional, thus it is limited and we cannot infer causality. In addition, the study was based on self-report which might be critical concerning some variables (BMI, see below) and others not (e.g. sleep variables).

One limitation of the study is the self-reporting of weight and height which usually leads to an underestimation of BMI. This systematic under-reporting of weight may have affected the results and it may have reduced the power to detect an effect (because fewer children are at the heavier end of the BMI spectrum). However, we placed a ruler and a weigh in the classroom for the pupils which could have improved the self-reporting.

The NSE scale has been recently developed and seems an appropriate tool for adolescents but needs further evaluation to provide convergent and discriminant validity. Further, we did not measure social deprivation.

Further studies should also collect data on other aspects like physical activity but epidemiological studies in schools always face the problem of time constraints and willingness to participate.

Conclusions

To advance the field further, chronotype should be incorporated in further research in obesity. Further, researchers and clinician may be aware of the bed times as one possible point for interventions to prevent obesity. Recent studies suggest that chronotype could be – at least to some extent – changed to morningness when parents set the bed times (Randler et al., 2009).

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References

AbuSabha, R., & Achterberg, C. (1997). Review of self-efficacy and locus of control for nutrition- and health-related behavior. *Journal of the American Dietetic Association, 97*, 1122-1132. doi:10.1016/S0002-8223(97)00273-3

Adan, A., Archer, S. N., Hidalgo, M. P., Di Milia, L., Natale, V., & Randler, C. (2012). Circadian typology: A comprehensive review. *Chronobiology International, 29*, 1153-1175. doi:10.3109/07420528.2012.719971

Anic, G. M., Titus-Ernstoff, L., Newcomb, P. A., Trentham-Dietz, A., & Egan, K. M. (2010). Sleep duration and obesity in a population-based study. *Sleep Medicine, 11*, 447-451. doi:10.1016/j.sleep.2009.11.013

Baron, K. G., Reid, K. J., Kern, A. S., & Zee, P. C. (2011). Role of sleep timing in caloric intake and BMI. *Obesity, 19*, 1374-1381. doi:10.1038/oby.2011.100

Bas, M., & Donmez, S. (2009). Self-efficacy and restrained eating in relation to weight loss among overweight men and women in Turkey. *Appetite, 52*, 209-216. doi:10.1016/j.appet.2008.09.017

Brener, N. D., Mcmanus, T., Galuska, D. A., Lowry, R., & Wechsler, H. (2003). Reliability and validity of self-reported height and weight among high school students. *The Journal of Adolescent Health, 32*, 281-287. doi:10.1016/S1054-139X(02)00708-5

Chaput, J. P., Brunet, M., & Tremblay, A. (2006). Relationship between short sleeping hours and childhood overweight/obesity: Results from the 'Quebec en Forme' project. *International Journal of Obesity, 30*, 1080-1085. doi:10.1038/sj.ijo.0803291

Chaput, J. P., Després, J.-P., Bouchard, C., & Tremblay, A. (2012). Longer sleep duration associates with lower adiposity gain in adult short sleepers. *International Journal of Obesity, 36*, 752-756. doi:10.1038/ijo.2011.110

Chaput, J. P., & Tremblay, A. (2007). Does short sleep duration favor abdominal adiposity in children? *International Journal of Pediatric Obesity, 2*, 188-191. doi:10.1080/17477160701306144

Contento, I. R., Randell, J. S., & Basch, C. E. (2002). Review and analysis of education measures used in nutrition education intervention research. *Journal of Nutrition Education and Behavior, 34*, 2-25. doi:10.1016/S1499-4046(06)60220-0

Delahanty, L. M., Meigs, J. B., Hayden, D., Williamson, D. A., & Nathan, D. M. (2002). Psychological and behavioral correlates of baseline BMI in the Diabetes Prevention Program (DPP). *Diabetes Care, 25*, 1992-1998. doi:10.2337/diacare.25.11.1992

Dollman, J., Ridley, K., Olds, T., & Lowe, E. (2007). Trends in the duration of school-day sleep among 10- to 15-year-old South Australians between 1985 and 2004. *Acta Paediatrica, 96*, 1011-1014. doi:10.1111/j.1651-2227.2007.00278.x

Eisenmann, J. C., Ekkekakis, P., & Holmes, M. (2006). Sleep duration and overweight among Australian children and adolescents. *Acta Paediatrica, 95*, 956-963. doi:10.1080/08035250600731965

Fleig, D., & Randler, C. (2009). Association between chronotype and diet in adolescents based on food logs. *Eating Behaviors, 10*, 115-118. doi:10.1016/j.eatbeh.2009.03.002

Kaneva, N., Kronholm, E., Partonen, T., Ovaskainen, M.-L., Kaartinen, N. E., Konttinen, H., & Männistö, S. (2012). Tendency toward eveningness is associated with unhealthy dietary habits. *Chronobiology International, 29*, 920-927. doi:10.3109/07420528.2012.699128

Kluge, M., Schüssler, P., Zuber, V., Yassouridis, A., & Steiger, A. (2007). Ghrelin administered in the early morning increases secretion of cortisol and growth hormone without affecting sleep. *Psychoneuroendocrinology, 32*, 287-292. doi:10.1016/j.psyneuen.2006.12.015

Lach, J. (2003). Gesundheitsförderndes Ernährungsverhalten von Jugendlichen und die Konsequenzen für die schulische Praxis. *Empirische Pädagogik, 17*, 39-56.

Li, S., Zhu, S., Jin, X., Yan, C., Wue, S., Jiang, F., & Shen, X. (2010). Risk factors associated with short sleep duration among Chinese school-aged children. *Sleep Medicine, 11*, 907-916. doi:10.1016/j.sleep.2010.03.018

Lumeng, J. C., Somashekar, D., Appugliese, D., Kaciroti, N., Corwyn, R. F., & Bradley, R. H. (2007). Shorter sleep duration is associated with increased risk for being overweight at ages 9 to 12 years. *Pediatrics, 120*, 1020-1029. doi:10.1542/peds.2006-3295

Luszczynska, A., Tryburcy, M., & Schwarzer, R. (2007). Improving fruit and vegetable consumption: A self-efficacy intervention compared with a combined self-efficacy and planning intervention. *Health Education Research, 22*, 630-638. doi:10.1093/her/cyl133

Magee, C. A., Iverson, D. C., Huang, X. F., & Caputi, P. (2008). A link between chronic sleep restriction and obesity: Methodological considerations. *Public Health, 122*, 1373-1381. doi:10.1016/j.puhe.2008.05.010

Meule, A., Roeser, K., Randler, C., & Kübler, A. (2012). Skipping breakfast: Morningness-eveningness preference is differentially related to state and trait food cravings. *Eating and Weight Disorders, 17*(4), e304-e308.

Randler, C. (2011). Age and gender differences in morningness-eveningness during adolescence. *The Journal of Genetic Psychology, 172*, 302-308. doi:10.1080/00221325.2010.535225

Randler, C., Bilger, S., & Díaz–Morales, J. F. (2009). Association between sleep, chronotype, parental monitoring and pubertal development in German adolescents. *The Journal of Psychology, 143*, 509-520. doi:10.3200/JRL.143.5.509-520

Randler, C., & Schaal, S. (2010). Morningness-eveningness, habitual sleep-wake variables and cortisol levels. *Biological Psychology, 85*, 14-18. doi:10.1016/j.biopsycho.2010.04.006

Roach, J. B., Yadrick, M. K., Johnson, J. T., Boudreaux, L. J., Forsythe, W. A., III, & Billon, W. (2003). Using self-efficacy to predict weight loss among young adults. *Journal of the American Dietetic Association, 103*, 1357-1359. doi:10.1016/S0002-8223(03)01072-1

Roenneberg, T., Allebrandt, K. V., Merrow, M., & Vetter, C. (2012). Social jetlag and obesity. *Current Biology, 22*, 939-943. doi:10.1016/j.cub.2012.03.038

Roenneberg, T., Kuehnle, T., Pramstaller, P. P., Ricken, J., Havel, M., Guth, A., & Merrow, M. (2004). A marker for the end of adolescence. *Current Biology, 14*, R1038-R1039. doi:10.1016/j.cub.2004.11.039

Sabiston, C. M., & Crocker, P. R. E. (2008). Examining an integrative model of physical activity and healthy eating behaviors among adolescents. *The Journal of Adolescent Health, 42*, 64-72. doi:10.1016/j.jadohealth.2007.08.005

Schaal, S. (2013). Becoming a health promoting school: Effects of a 3 year intervention on school development and pupils. In C. Bruguiére, A. Tiberghien, & P. Clément (Eds.), *ESERA 2011 selected contributions: Topics and trends in current science education.* Dodrecht: Springer.

Schwarzer, R. (2008). Modeling health behavior change: How to predict and modify the adoption and maintenance of health behaviors. *Applied Psychology, 57*, 1-29. doi:10.1111/j.1464-0597.2007.00325.x

Snell, E. K., Adam, E. K., & Duncan, G. J. (2007). Sleep and the Body Mass Index and overweight status of children and adolescents. *Child Development, 78*, 309-323. doi:10.1111/j.1467-8624.2007.00999.x

Taveras, E. M., Rifas-Shiman, S. L., Oken, E., Gunderson, E. P., & Gillman, M. W. (2008). Short sleep duration in infancy and risk of childhood overweight. *Archives of Pediatrics & Adolescent Medicine, 162*, 305-311. doi:10.1001/archpedi.162.4.305

Wittmann, M., Dinich, J., Merrow, M., & Roenneberg, T. (2006). Social jetlag: Misalignment of biological and social time. *Chronobiology International, 23*, 497-509. doi:10.1080/07420520500545979

Ziegelmann, J. P., & Lippke, S. (Eds.). (2009). Theory-based approaches to stress and coping: Emerging themes and contemporary research [Special issue]. *European Psychologist, 14*(1).

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