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Original Article

Is it time for bed? Short sleep duration increases risk of obesity in Mexican American children

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ABSTRACT

Objective: Cross-sectional studies show that sleep is related to childhood obesity. We aimed to examine the longitudinal impact of sleep on the risk of obesity in Mexican American children.
Design and methods: We evaluated 229 Mexican American 8–10-year-olds and their mothers at baseline and at 12- and 24-month follow-ups. Sleep duration and anthropometrics were collected. Age- and gender-specific body mass index (BMI) *z*-scores (BMIz) were calculated based on Centers for Disease Control and Prevention guidelines. Sleep duration was estimated using accelerometry. Children were also categorized as long or short sleepers, using the National Sleep Foundation's recommendation to define adequate sleep duration (10–11 h for 5–12-year-olds). Using linear regressions, we examined whether sleep duration predicted BMIz, waist-to-height ratio (WHtR), and weight gain at 24 months.
Results: Children were mostly short sleepers (82%). Children who slept less were more likely to have a higher BMIz, WHtR, and weight gain at the 24-month follow-up ($\beta = -0.07$, $P = 0.01$; $\beta = -0.11$, $P < 0.01$; and $\beta = -0.14$, $P = 0.02$, respectively), after controlling for baseline weight status, child gender, maternal BMI, and occupation.
Conclusion: In Mexican American children, shorter sleep duration at baseline was associated with increased weight status over 24 months.

1. Introduction

The National Sleep Foundation (NSF) recommends 10–11 h of nighttime sleep for school-age children (ages 5–12) to obtain adequate rest [1]. Emerging research has detected insufficient sleep as early as preschool age [2,3], with an expected decline in sleep duration of up to 2.5 h by adolescence and a notable decline in sleep at age 9 [3]. In a study of 3–6-year-olds, Latinos were more likely to have a bedtime at/later than 9 PM compared with children of other ethnic groups [4]. Cross-sectional studies have examined the relationship between children's sleep and obesity [5], with findings showing that they are significantly related [6–9], yet the impact of short sleep duration on the risk of obesity has yet to be established among Latino children.

Latino children suffer some of the highest obesity rates, putting them at an increased risk of childhood metabolic disturbances, lifelong obesity, and type 2 diabetes [10]. The health disparities in this population demonstrate the urgency to understand Latino children's sleep duration. To date, few studies have examined sleep in Latinos, but findings suggest that they are at the risk of insufficient sleep, a trend that may be increasing. The Alameda County Health Study found that, in 1965, Latino adults were less likely to have short sleep duration compared with non-Latino whites. At follow-up, 34 years later (1999), Latino adults had a higher predicted probability of short sleep compared to other ethnic groups [11]. Sleep-disordered breathing is also frequent among Latinos and therefore poor sleep is expected to be frequent [12]. In a study of Mexican American families, less nighttime sleep was associated with poor well-being (depressive symptoms, risky behaviors and higher body mass index or BMI) in both seventh graders and their older siblings [13]. To effectively address obesity among Latino children,

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longitudinal studies are warranted to establish whether insufficient sleep influences obesity in this population.

Cross-sectional findings empirically support the sleep–obesity relationship in boys and girls [8,9,14]. Several longitudinal studies found that sleep duration impacts obesity in boys and girls [14–17]. Other studies, however, showed that sleep mattered more for the development of obesity in boys than in girls [18,19], and others did not find that sleep predicted obesity in either boys or girls [20]. One possible explanation for the discrepant findings could be due to the questionable reliability of sleep measurement in most studies. Most studies have used self-report, including participants' usual bedtime and waking time [7,8,18–22]. Studies involving younger children have relied on parent-reported sleep duration [19]. Inconsistency in measurement approaches makes it difficult to compare findings across studies. Furthermore, a more reliable sleep measure could help disentangle whether there are gender differences in the sleep–obesity relationship.

Using the NSF sleep recommendation to examine the sleep–pediatric obesity connection would be helpful in determining whether 10 h is sufficient to protect school-age children from obesity, particularly Latino children. An enhanced understanding of how insufficient sleep impacts child weight status could help address obesity because childhood sleep patterns may persist into adulthood. Moreover, using a more reliable sleep measure could help yield more consistent results across studies. The purpose of this study was to examine the impact of sleep duration on weight status in Mexican American children. Sleep was measured using accelerometry. We hypothesized that short sleep duration would increase the risk of increased adiposity at the 24-month follow-up assessment. In addition, we explored gender differences in this relationship.

2. Methods

2.1. Design and participants

We recruited Mexican American children and their mothers to participate in a 24-month longitudinal cohort study to understand parental influences on obesity in Mexican American children [23]. Mothers were members of Kaiser Permanente Northern California, an integrated health delivery system, between 2007 and 2009. The eligibility criteria for participation included a mother of Mexican descent (Mexican/U.S. born) and a child between 8 and 10 years of age, with no major illnesses. Mothers and children received written and oral information explaining the purpose and the design of the study. We obtained parental informed consent and child assent to participate in the study. Families were interviewed during home visits at baseline (BL), and 12- and 24-month follow-ups. A total of 326 families were enrolled at BL. Among these, 232 children had complete data on BMI at the 24-month follow-up and complete sleep data at two of the three assessments (BL, and 12- and 24-month follow-ups). We excluded three cases with missing data on maternal BMI, resulting in a final sample of 229 participants. The study was approved by the Institutional Review Boards at the University of California, San Francisco, and the Kaiser Permanente Northern California Research Foundation.

2.2. Procedure

Interviews were conducted by trained bilingual/bicultural research assistants, in the participants' preferred language. Each in-home interview and assessment lasted about 5 h. Children completed a parent-assisted interview. Research assistants collected the following information from mothers: maternal country of birth, occupational status, and their child's pubertal status, and they measured mother and child height, weight, and waist circumference. Research assistants entered all data on laptop computers. An activity monitor was left with each child for a 3-day assessment. At BL, the mother and child participants each received a $70 incentive.

2.3. Measures

2.3.1. Independent variable: sleep duration

Children's sleep was measured for three consecutive days, at all three assessments (BL, and 12- and 24-month follow-ups), using the Actical activity monitor (Actical, Philips Respironics, Bend, OR, USA). A duration of 3 days was chosen to reduce participant burden and maximize study participation. Actical is sensitive to movements in the 0.5–3-Hz range allowing for detection of sedentary movements as well as high-energy movements, and minimizes the effect of undesirable noise impulses, which tend to skew results. Additionally, sleep duration measured by hip-worn accelerometry has been found to be highly correlated ($r = 0.93$) with sleep duration measured with a wrist-worn accelerometer in children aged 10–11 years [24]. Each activity monitor was programmed to collect data at 60-s intervals, on a specified start date and time. Monitors were worn on an elastic belt above the child's right hip. During the home visit, research assistants demonstrated how to wear the belt to both mother and child, and provided written instructions for proper care. Children were asked to wear the monitors at all times for three consecutive days (two weekdays and one weekend day), excluding baths.

Sleep duration was determined by a qualified technician using the activity count value per minute (cpm) data. The time of sleep onset was identified as the point when cpm changed to consecutive zeroes lasting about 8–10 h (typical nighttime sleep duration). During this period, occasional activity <150 cpm (indicative of very low-intensity movement during sleep) was not counted as awake time. The termination of night sleep was identified by an abrupt increase in activity counts >150 cpm that lasted several minutes, indicative of awakening and getting out of bed. Any minutes scored >150 cpm during the night were considered awake and were removed from the sleep duration. Nighttime sleep duration was computed as the mean of the three consecutive 24-h accelerometer sleep duration estimates for each assessment (BL, and 12- and 24-month follow-ups) [9]. Sleep duration at BL was used as the independent variable in analyses.

Additionally, we created a variable to describe child sleep duration type during the 24-month period, using the NSF recommendation for 5–12-year-olds. Considering nighttime sleep duration at the three assessments, we classified children by sleep duration type: children who slept ≥10 h at two assessments were coded as long sleepers [1]; children who slept <10 h at two assessments were coded as short sleepers [2].

2.3.2. Outcome variables: body mass index z-score (BMIz), waist-to-height ratio, and weight gain at 24 months

At BL and 12- and 24-month follow-ups, child height, weight, and waist circumference were obtained using standard procedures, and in duplicate while the participants were wearing light indoor clothing and no shoes [25,26]. The children's BMI was calculated (weight (kg)/height (m) [2]), converted to age- and gender-specific percentiles, and converted to *z*-scores using National Child Health Statistics growth charts [27]. Waist-to-height ratio (WHtR) was used as a measure of the distribution of adiposity. WHtR was obtained by dividing the child's waist circumference by their height. As a clinical measure, WHtR should be <0.5, reflecting the standard that an individual's waist circumference should be less than half their height [28]. Weight gain was calculated (24-month follow-up weight (kg) – baseline weight (kg)). Because we did not detect significant differences in weight status from BL to the 12-month follow-up, the 12-month weight status was excluded from analyses. Others have examined weight status using follow-up periods of 2–3 years, given that the change in weight status within a 12-month period may be small [15,16,20,29].

2.3.3. Covariates: child gender, age, pubertal status, and maternal BMI and occupation

We controlled for child characteristics, including gender (boy [1], girl [2]), age, and pubertal status at BL. Pubertal status was included as a potential covariate because it has been associated with obesity in previous studies [30]. We used the five-item Pubertal Development Scale, which was completed by mothers at BL [31]. This measure, with versions for males and females, asks about physical development on characteristics associated with physical maturation, with response options ranging from *no* [1] to *yes, a lot* [3]. Separate mean scores were calculated for each gender. Lastly, we controlled for sleep duration at the 12-month follow-up.

We controlled for mother's country of birth, BMI, and occupational status [32]. Occupational status ranged from *unskilled* [1] to *professional* [9].

2.4. Statistical analyses

We used Mplus, Version 7 (Los Angeles, CA, USA), and SPSS, Version 20 (SPSS Inc, Chicago, IL, USA), to perform statistical analyses.

We used MPlus to find data patterns of missingness. We observed one missing data pattern when sleep patterns and adiposity outcomes were jointly considered. Using SPSS, analyses of variance and chi-squared tests of independence were performed to determine if the missing pattern was related to demographic variables. There were no statistical differences detected between those with and without complete data for this missing data pattern.

We evaluated the influence of sleep duration at BL on BMIz, WHtR, and weight gain at 24 months using multivariate linear regressions. The regression models for all outcomes included sleep duration (BL) and were adjusted for retained covariates. Lastly, we added a sleep duration (BL) by gender interaction term to the regression models.

3. Results

3.1. Descriptives

Table 1 presents the descriptive statistics for children and their mothers. The mean BMIz for children were 0.97 (standard deviation (SD) = 1.0) and 0.91 (SD = 1.1) at BL and 24-month follow-up, respectively. The mean WHtR was 0.5 (SD = 0.1) at both assessments, with a mean 24-month weight gain of 11 kg (SD = 5.3).

The descriptive statistics for children's 3-day mean sleep duration at BL, and 12- and 24-month follow-ups are presented in Table 1. Children slept an average of 9.5 h ($n = 229$), 9.6 h ($n = 215$), and 9.4 h ($n = 214$) at BL, 12 months, and 24 months, respectively. Note that at BL, the full sample had complete data on sleep duration, with several children missing data at the 12- or 24-month follow-ups. This yielded 229 children with sufficient sleep duration data at two of the three assessments to be classified as either short or long sleepers. Considering all three assessments, the majority of the children were classified as short sleepers [82% ($n = 187$)], with only 18% ($n = 42$) meeting the NSF's sleep recommendation for their age.

3.2. Primary analyses

In the unadjusted model examining BMIz as the health outcome (Table 2), longer sleep duration at BL was associated with a lower 24-month BMIz ($\beta = -0.22$, $P < 0.001$). In the adjusted model, children who slept longer had significantly lower 24-month BMIz ($\beta = -0.07$, $P = 0.01$). Prior BMIz at BL, but not occupational status, was highly associated with significant BMIz at the 24-month follow-up ($\beta = 0.88$, $P < 0.001$). Other covariates were not significant and were not included in the final model.

In the unadjusted model examining WHtR as the health outcome (Table 3), longer sleep duration at BL was associated with lower 24-month WHtR ($\beta = -0.25$, $P < 0.001$). In the adjusted model, children

Table 1
Sample characteristics for Mexican American children and their mothers ($n = 229$).

	Mean (SD) or *n*, %	Short sleepers Mean (SD) or *n*, % ($n = 187$, 82%)	Long sleepers Mean (SD) or *n*, % ($n = 42$, 18%)
Time 1			
Mother			
Age	37.2 (6.3)	37.1 (6.2)	37.9 (6.5)
BMI	30.5 (6.9)	30.7 (6.7)	29.7 (7.8)
U.S. born	53, 25.4	41, 22.0	13, 31.0
Occupational status[a]	3.2 (2.0)	3.2 (2.0)	3.6 (2.2)
Child			
Male	106, 46.3	87, 46.5	19, 45.2
Age	8.8 (0.8)	8.9 (0.8)	8.7 (0.8)
8 years old	98, 42.8	77, 41.2	21, 50.0
9 years old	74, 32.3	62, 33.2	12, 28.6
10 years old	57, 24.9	48, 25.7	9, 21.4
Sleep duration	9.54 (0.71)	9.37 (0.59)	10.31 (0.71)
Puberty status	1.30 (0.3)	1.31 (0.3)	01.24 (0.2)
BMI *z*-score	0.97 (1.0)	1.05 (0.98)	0.51 (1.00)
WHtR	0.50 (0.1)	0.49 (0.08)	0.47 (0.06)
Time 2 (Child)			
Sleep duration ($n = 215$)	9.62 (0.77)	9.45 (0.69)	10.43 (0.61)
Time 3 (Child)			
Sleep duration ($n = 214$)	9.41 (0.74)	9.22 (0.59)	10.24 (0.75)
BMI *z*-score	0.91 (1.10)	1.04 (0.32)	0.32 (1.27)
WHtR	0.50 (0.08)	0.51 (0.06)	0.46 (0.06)
Weight gain (kg)	11.0 (5.3)	11.4 (5.2)	9.0 (5.2)
Height gain (cm)	12.4 (2.9)	12.3 (3.0)	12.7 (2.4)

[a] Mean score equivalent to semiskilled worker.

Table 2
Longitudinal bivariate and multivariate associations between sleep duration at baseline (BL) and BMI *z*-score at 24-month follow-up.

Predictor	Unadjusted model			Adjusted model		
	β	*P*	R^2	*β*	*P*	R^2
Sleep duration (BL)	–0.22	<0.001	0.04	–0.07	0.01	0.82
Covariates						
BMI *z*-score (BL)				0.88	<0.001	
Occupation status				–0.05	0.07	

who slept longer had significantly lower 24-month WHtR ($\beta = -0.11$, $P < 0.01$). Significant covariates included BL WHtR ($\beta = 0.81$, $P < 0.001$), gender ($\beta = -0.08$, $P = 0.02$), and occupational status ($\beta = -0.10$, $P = 0.04$). Other covariates were not significant and not included in the final model.

In the unadjusted model examining weight gain as the health outcome (Table 4), longer sleep duration at BL was associated with lower weight gain from BL to 24 months ($\beta = -0.23$, $P = 0.001$). In the adjusted model, children who slept longer had significantly lower weight gain at 24 months ($\beta = -0.14$, $P = 0.02$). Significant covariates included sleep duration at the 12-month follow-up ($\beta = -0.15$, $P = 0.01$), BL to 24-month follow-up height gain ($\beta = 0.41$, $P = 0.01$), and mother's BMI ($\beta = 0.27$, $P < 0.001$), whereas occupational status ($\beta = -0.13$, $P = 0.03$) was not a significant covariate. Other covariates were not significant and not included in the final model.

Sleep duration did not differ by gender. We tested for a sleep duration by gender interaction in relation to BMIz, WHtR, and weight gain, which was not significant in any model.

4. Discussion

Mexican Americans make up the largest segment of the U.S. Latino population [33]. In this sample of Mexican American children, only 18% met the NSF sleep recommendation for their age. The sleep duration at BL was associated with weight outcomes 2 years later, in both boys and girls. Specifically, longer sleep duration was associated with lower BMIz, a relationship that did not change even after adjusting for prior BMIz and occupational status. In addition, longer sleep duration was associated with lower WHtR and weight gain, while controlling for prior WHtR or height gain, child gender, maternal BMI, and occupational status.

The current findings support the hypothesis that increased sleep duration is protective against subsequent increased weight status, and extend previous cross-sectional research examining the associations between sleep duration and pediatric obesity. We measured sleep duration using accelerometry at three annual assessments. Within each assessment, sleep was measured for three consecutive days. Consequently, we were able to estimate sleep duration at each time point with more accuracy. This method allowed us to estimate actual time spent sleeping, compared to reporting what time the child typically goes to bed and what time the child wakes up. As such, we reliably examined the association between sleep and weight status [34]. By contrast, Araujo et al. examined self-reported sleep duration at age 13 on BMI at ages 13 and 17 and only found cross-sectional associations [20]. Self-reported sleep may be an adequate measure of sleep for cross-sectional investigations, but may be inadequate for examining sleep longitudinally. This may be due to the reliance on parental report of children's sleep, which may not account for sleep latency, but may be acceptable for providing a general estimate of children's sleep duration at a single time point. However, the unreliability of parental report becomes a greater problem when sleep duration estimates are collected over time in this way, as parents tend to overestimate sleep duration.

We examined three measures of children's weight status, with bivariate results showing that sleep duration was associated with all three measures. The relationship between sleep duration and BMIz was attenuated, but still significant after controlling for prior weight status, which, as expected, is strongly related to future weight status. Similarly, sleep duration was associated with both WHtR and weight gain while controlling for covariates, including prior weight status or height gain, sleep duration at 12-month follow-up, and maternal BMI and occupational status. At the 24-month follow-up, female gender was associated with lower WHtR, maternal BMI was associated with increased weight gain, and past weight status or height gain was associated with weight status. Generally, these covariates are known to influence obesity in children [35]. Sleep duration at the 12-month follow-up was also significantly related to weight gain, which suggests that sleep over time may have an additive effect on child weight status. Additionally, we found an association between sleep duration and WHtR, which is worth mentioning. WHtR may be a better measure for examining weight status and/or central adiposity in this group because BMIz may be less sensitive to extreme scores, as well as changes over time [28,36]. As such, there may have been a better distinction between the scores of children in the highest percentiles, when using WHtR, compared to BMIz. This may be true especially in this sample because 50% of children were >85th percentile for weight and age.

It is important to note that most children (82%) in this sample slept less than the recommended 10 h at most assessments. Sleep duration increased by about 5 min from BL to 12 months, but decreased from 12 to 24 months by about 13 min. The latter is consistent with others' findings that sleep decreases with age [3]. Although the reasons for sleep duration decline may be biological, social, cultural, or environmental, there are several potential clinical implications. Parents may not be aware of the amount of time children are required to sleep to feel rested. Clinicians should screen and counsel families about the importance of children's sleep. As there are contextual factors in the household that may be interfering with the child's ability to fall asleep (eg, room/bed sharing, crowded home, or loud noises), it may be necessary to provide families with additional tools and resources to change children's sleeping habits or sleep environment. Lastly, sleep did not differ by gender, but such differences may emerge at later ages, once puberty is reached [37].

Table 3
Longitudinal bivariate and multivariate associations between sleep duration at baseline (BL) and waist-to-height ratio (WHtR) at 24-month follow-up.

Predictor	Unadjusted model			Adjusted model		
	β	*P*	R^2	*β*	*P*	R^2
Sleep duration (BL)	–0.25	<0.001	0.06	–0.11	<0.01	0.73
Covariates						
Waist-to-height ratio (BL)				0.81	<0.001	
Female				–0.08	0.02	
Occupation status				–0.07	0.06	

Table 4
Longitudinal bivariate and multivariate associations between sleep duration at baseline (BL) and weight gain (kg) from baseline to 24-month follow-up.

Predictor	Unadjusted model			Adjusted model		
	β	*P*	R^2	*β*	*P*	R^2
Sleep duration (BL)	–0.23	0.001	0.05	–0.14	0.02	0.31
Covariates						
Sleep duration (12m)				–0.15	0.01	
Height gain (BL to 24m)				0.41	<0.001	
Maternal BMI				0.27	<0.001	
Occupation status				–0.10	0.08	

12m = 12-month assessment; 24m = 24-month assessment.

This study has several limitations. First, we studied children from middle to late childhood and therefore these findings should not be generalized beyond this age range. This study was conducted with Mexican American children; these findings may not be generalizable to other Latino subgroups or other ethnic groups. Future studies could examine these relationships in younger children, other Latino subgroups, and other ethnic groups. Future research could also help to identify cultural, social, or environmental factors that may play a role in Latino children's sleep. Last, we assessed sleep using accelerometers used on the hip as opposed to using wrist actigraphs, which are typically used for sleep measurement and worn on the non-dominant wrist; however, several studies have used hip-worn accelerometry to assess sleep in children, and it is highly correlated with wrist-worn actigraphs [24,38]. Polysomnography is the gold standard for sleep studies, but it is expensive, subject burden is high, and it is not suitable for large epidemiological studies.

The current study had several strengths, including the longitudinal design. Moreover, we used accelerometry to measure sleep, and accordingly we were able to more reliably estimate sleep duration over time. Accelerometer estimation may be the best approach when assessing sleep longitudinally as it minimizes error at multiple time points as opposed to reported sleep, which is subject to recall bias and misreport, and, with multiple assessments, is open to greater error. Because parents overestimate their child's sleep duration, this could limit researchers' ability to determine whether children sleep adequately [9]. In addition, when examining the association between sleep duration and obesity, using accelerometry may result in more accurate and reliable results. Lastly, our analysis included maternal BMI, which has not been controlled for in many studies examining the relationship between sleep and pediatric obesity [6].

In summary, among Mexican American boys and girls, children who slept less at BL were at a greater risk of increased BMIz, WHtR, and weight gain at the 24-month follow up. Consistent with previous research in other populations [8,14,16], these findings confirm the association of shorter sleep duration with the risk of obesity in Mexican American children in the U.S. and underscore the importance of optimal sleep among children. While the mechanisms explaining the relationship between sleep and obesity remain unclear, these findings suggest counseling Mexican American parents on the importance of sleep in protecting their children from obesity. For clinicians, asking parents about their child's nighttime sleep duration may be necessary to promote sufficient sleep among short sleepers. Lastly, interventions could target improving sleep duration as an important component in addressing childhood obesity.

Conflict of interest

The ICMJE Uniform Disclosure Form for Potential Conflicts of Interest associated with this article can be viewed by clicking on the following link: http://dx.doi.org/10.1016/j.sleep.2014.09.009.

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SM conceptualized and designed the study, conducted the data analysis, contributed substantially to the interpretation of the data, and drafted the initial manuscript.LG and JM substantially contributed to the conception and design of the study and acquisition of data.JM assisted with data analysis and interpretation, and revised the article critically for important intellectual content.JD, NFB, and SG substantially contributed to the acquisition of data and data collection instruments, assisted with data analysis and interpretation, and critically reviewed the manuscript.CP, LA, and EF substantially contributed to the acquisition of data, revised the article critically for important intellectual content, and provided feedback on several drafts.All authors approved the final manuscript as submitted.

References

[1] National Sleep Foundation. 2007. Available at: <http://www.sleepfoundation.org/article/sleep-topics/children-and-sleep> (accessed September 28, 2012).
[2] Owens JA, Jones C. Parental knowledge of healthy sleep in young children: results of a primary care clinic survey. JDBP 2011;32(6):447–53.
[3] Snell EK, Adam EK, Duncan GJ. Sleep and the body mass index and overweight status of children and adolescents. Child Dev 2007;78(1):309–23.
[4] Hale L, Berger LM, LeBourgeois MK, Brooks-Gunn J. Social and demographic predictors of preschoolers' bedtime routines. JDBP 2009;30:394–402.
[5] Flint J, Kothare SV, Zihlif M, Suarez E, Adams R, Legido A, et al. Association between inadequate sleep and insulin resistance in obese children. J Pediatr 2007;150(4):364–9.
[6] Chen X, Beydoun MA, Wang Y. Is sleep duration associated with childhood obesity: a systematic review and meta-analysis. Obesity 2008;16(2):265–74.
[7] Wells JCK, Hallal PC, Reichert FF, Menezes AMB, Araujo CLP, Victora CG. Sleep patterns and television viewing in relation to obesity and blood pressure: evidence from an adolescent Brazilian birth cohort. Int J Obes 2008;32(7):1042–9.
[8] Danielsen YS, Pallesen S, Stormark KM, Nordhus IH, Bjorvatn B. The relationship between school day sleep duration and body mass index in Norwegian children (aged 10–12). Int J Pediatr Obes 2010;5(3):214–20.
[9] Martinez S, Greenspan L, Tschann J, de Groat C, Gregorich S, Butte N, et al. Mother-reported sleep, accelerometer-estimated sleep and weight status in Mexican American children: sleep duration is associated with increased adiposity and risk for overweight/obese status. J Sleep Res 2014; 23(3):326–34.
[10] Ogden CL, Carroll MD, Curtin LR, Lamb MM, Flegal KM. Prevalence of high body mass index in US children and adolescents, 2007–2008. JAMA 2010;303(3):242–9.
[11] Stamatakis KA, Kaplan GA, Roberts RE. Short sleep duration across income, education, and Race/Ethnic groups: population prevalence and growing disparities during 34 years of follow-up. Ann Epidemiol 2007;17(12):948–55.
[12] Loredo JS, Soler X, Bardwell W, Ancoli-Israel S, Dimsdale JE, Palinkas LA. Sleep health in US Hispanic population. Sleep 2010;33(7):962–7.
[13] McHale SM, Kim JY, Kan M, Updegraff KA. Sleep in Mexican-American adolescents: social ecological and well-being correlates. J Youth Adolesc 2011;40(6):666–79.
[14] Touchette E, Petit D, Tremblay RE, Boivin M, Falissard B, Genolini C, et al. Associations between sleep duration patterns and overweight/obesity at age 6. Sleep 2008;31(11):1507–14.
[15] Agras WS, Hammer LD, McNicholas F, Kraemer HC. Risk factors for childhood overweight: a prospective study from birth to 9.5 years. J Pediatr 2004;145(1):20–5.
[16] Lumeng JC, Somashekar D, Appugliese D, Kaciroti N, Corwyn RF, Bradley RH. Shorter sleep duration is associated with increased risk for being overweight at ages 9 to 12 years. Pediatrics 2007;120(5):1020–9.
[17] Reilly JJ, Armstrong J, Dorosty AR, Emmett PM, Ness A, Rogers I, et al. Early life risk factors for obesity in childhood: cohort study. BMJ 2005;330(7504):1357.
[18] Eisenmann JC, Ekkekakis P, Holmes M. Sleep duration and overweight among Australian children and adolescents. Acta Pædiatrica 2006;95(8):956–63.
[19] Tatone-Tokuda F, Dubois L, Ramsay T, Girard M, Touchette E, Petit D, et al. Sex differences in the association between sleep duration, diet and body mass index: a birth cohort study. J Sleep Res 2012;21(4):448–60.
[20] Araujo J, Severo M, Ramos E. Sleep duration and adiposity during adolescence. Pediatrics 2012;130(5):E1146–54.
[21] Knutson KL. Sex differences in the association between sleep and body mass index in adolescents. J Pediatr 2005;147(6):830–4.
[22] Seicean A, Redline S, Seicean S, Kirchner HL, Gao Y, Sekine M, et al. Association between short sleeping hours and overweight in adolescents: results from a US Suburban High School survey. Sleep Breath 2007;11(4):285–93.
[23] Tschann JM, Gregorich SE, Penilla C, Pasch LA, de Groat CL, Flores E, et al. Parental feeding practices in Mexican American families: initial test of an expanded measure. Int J Behav Nutr Phys Act 2013;10(1):1–11.
[24] Kinder JR, Lee KA, Thompson H, Hicks K, Topp K, Madsen KA. Validation of a hip-worn accelerometer in measuring sleep time in children. J Pediatr Nurs 2012;27:127–33.
[25] Stallings VA, Fung EB. Clinical nutritional assessment of infants and children. In: Shils ME, Olson JA, Shike M, Ross AC, editors. Modern nutrition in health and disease. 9th ed. Philadelphia: Lippincott, Williams & Wilkins; 1999. p. 885–93.
[26] Lohman TG, Roche AF, Martorell R. Anthropometric standardization reference manual. Champaign, IL: Human Kinetics Books; 1989.
[27] Kuczmarski RJ, Ogden CL, Grummer-Strawn LM, Flegal KM, Guo SS, Wei R, et al. CDC growth charts: United States. Adv Data 2000;314:1–27.
[28] McCarthy HD, Ashwell M. A study of central fatness using waist-to-height ratios in UK children and adolescents over two decades supports the simple message - "keep your waist circumference to less than half your height". Int J Obes 2006;30(6):988–92.

[29] Bartle N, Hill C, Webber L, van Jaarsveld C, Wardle J. Emergence and persistence of overweight and obesity in 7-to 11-year-old children. Obes Facts 2013;6(5):415–23.
[30] Biro FM, Khoury P, Morrison JA. Influence of obesity on timing of puberty. Int J Androl 2006;29(1):272–7.
[31] Petersen AC, Crockett L, Tobin-Richards M, Boxer A. Measuring pubertal status: reliability and validity of a self-report measure. University Park: Pennsylvania State University; 1985.
[32] Hollingshead AB. Four-factor index of social status. New Haven, CT: Department of Sociology, Yale University; 1975.
[33] Pew Research Center. Diverse origins: the Nation's 14 largest Hispanic – Origin Groups. 2013. Available at: <http://www.pewhispanic.org/files/2013/06/summary_report_final.pdf> (accessed April 11, 2014).
[34] Hjorth MF, Chaput JP, Damsgaard CT, Dalskov SM, Michaelsen KF, Tetens I, et al. Measure of sleep and physical activity by a single accelerometer: can a waist-worn Actigraph adequately measure sleep in children? Sleep Biol Rhythms 2012;10(4):328–35.
[35] Whitaker RC, Wright JA, Pepe MS, Seidel KD, Dietz WH. Predicting obesity in young adulthood from childhood and parental obesity. N Engl J Med 1997;337(13):869–73.
[36] Cole TJ, Faith MS, Pietrobelli A, Heo M. What is the best measure of adiposity change in growing children: BMI, BMI %, BMI z-score or BMI centile? Eur J Clin Nutr 2005;59(3):419–25.
[37] Roenneberg T, Kuehnle T, Pramstaller PP, Ricken J, Havel M, Guth A, et al. A marker for the end of adolescence. Curr Biol 2004;14(24):R1038–9.
[38] Nixon GM, Thompson JMD, Han DY, Becroft DM, Clark PM, Robinson E, et al. Short sleep duration in middle childhood: risk factors and consequences. Sleep 2008;31(1):71–8.