

Short Sleep Duration Is Independently Associated With Overweight and Obesity in Quebec Children

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ABSTRACT

Objective: To investigate the association of sleep duration with adiposity and to determine if caloric intake and physical activity mediate this relationship.

Methods: The Quebec Adiposity and Lifestyle Investigation in Youth (QUALITY) study is an ongoing longitudinal investigation of Caucasian children with at least one obese biological parent. Children (n=550) with an average age of 9.6 years (SD=0.9) who provided complete data at baseline were included in the cross-sectional analyses. Objective measures of adiposity (BMI Z-score, waist circumference, percent body fat measured by dual-energy X-ray absorptiometry), sleep duration and physical activity (accelerometer over 7 days), and diet (24-hour food recalls) were collected. Children were categorized into 4 groups according to sleep duration: <10 hours, 10-10.9 hours, 11-11.9 hours, and ≥12 hours of sleep per night.

Results: We observed a U-shaped relationship between sleep duration and all adiposity indices. None of energy intake, snacking, screen time or physical activity intensity differed significantly between sleep categories. After adjusting for age, sex, Tanner stage, highest educational level of the parents, total annual family income, and parental BMI, only short-duration sleepers (<10 hours) had an increased odds of overweight/obesity (OR 2.08, 95% CI 1.16-3.67). Addition of total energy intake and physical activity to the model did not change the association substantially (OR 2.05, 95% CI 1.15-3.63).

Conclusion: The present study provides evidence that short sleep duration is a risk factor for overweight and obesity in children, independent of potential covariates. These results further emphasize the need to add sleep duration to the determinants of obesity.

Key words: Adiposity; body mass index; body weight; children; energy balance; sleep loss; sleep deprivation

La traduction du résumé se trouve à la fin de l'article.

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The evidence that short sleep duration is a determinant of obesity is accumulating.^{1,2} However, little is known about possible mechanisms underpinning this association. In order to produce weight gain, reduced sleep duration must either increase energy intake and/or reduce energy expenditure. Lack of sleep has been reported to decrease plasma leptin levels, increase plasma ghrelin and cortisol levels, alter glucose homeostasis, and activate the orexin system, all of which impact the regulation of appetite.³⁻⁵ Lack of sleep could also lead to weight gain and obesity by increasing the time available for eating and by making the maintenance of a healthy lifestyle more difficult. In an environment in which food is highly palatable and readily available, caloric intake may be directly proportional to time spent awake, especially if a large proportion of the waking hours are spent in sedentary activities such as watching television when snacking is common.^{6,7} Furthermore, the increased fatigue and tiredness associated with sleeping too little may impact overall physical activity participation.

Dietary patterns and physical activity only partially explained the association between short sleep duration and obesity in recent cohort studies conducted in adults.⁸⁻¹⁰ Possible explanations for this observation include that i) self-reported measures of energy intake and physical activity are inaccurate, or ii) the mechanisms linking short sleep duration with obesity include things other than diet and physical activity. The objective of the present study was to examine the relation between sleep duration and obesity in a large cohort of Quebec children aged 8-10 years. Then, using three non-consecutive 24-hour diet recalls and objective measures of adiposity,

physical activity and sleep duration, we tested if the association between sleep duration and overweight/obesity was independent of total caloric intake, dietary patterns, level of physical activity and sedentary behaviours.

METHODS

Study population

The initial sample comprised 632 children enrolled in the Quebec Adiposity and Lifestyle Investigation in Youth (QUALITY) cohort,

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Conflict of Interest: None to declare.

Table 1. Characteristics of Children According to Sleep Duration Group

Variable	<10 Hours (n=126)	10-10.9 Hours (n=262)	11-11.9 Hours (n=96)	≥12 Hours (n=66)	p-value
Age (years)	9.8 ± 0.8	9.6 ± 0.9	9.3 ± 1.0	9.6 ± 0.9	0.01
Sex					
Boys	75 (60)	134 (51)	54 (56)	36 (55)	0.48
Girls	51 (40)	128 (49)	42 (44)	30 (45)	
Body weight (kg)	41.7 ± 11.9	36.8 ± 10.8	35.4 ± 10.0	40.4 ± 13.3	<0.001
BMI category*					
Obese	38 (30)	43 (17)	23 (24)	18 (27)	<0.001
Overweight	29 (23)	53 (20)	10 (10)	12 (18)	
Normal	59 (47)	166 (63)	63 (66)	36 (55)	
Waist circumference (cm)	71.0 ± 12.1	65.9 ± 11.4	65.0 ± 10.8	70.2 ± 15.0	<0.001
Parents' highest education level					
No parent with high school	(0)	4 (1)	1 (1)	2 (3)	0.23
1-2 parents with high school	7 (6)	12 (5)	9 (9)	7 (11)	
1-2 parents with CEGEP†	42 (33)	102 (39)	40 (42)	26 (39)	
1-2 parents with university	77 (61)	144 (55)	46 (48)	31 (47)	
Total annual family income‡	42,052 ± 19,207	43,427 ± 17,746	39,978 ± 17,889	40,281 ± 19,314	0.35

Note: Data are presented as mean ± SD or number (%).

* Obesity is defined as a BMI ≥95th percentile, overweight as a BMI ≥85th and <95th percentile, and normal as a BMI ≥5th and <85th percentile.

† In Quebec, CEGEP is a level of education of 2 or 3 years between high school and university.

‡ Canadian dollars (CAD).

Statistical significance was assessed by analysis of variance with continuous variables and by a chi-squared test with categorical variables.

a familial study on the determinants of cardiovascular disease and type 2 diabetes in children. Caucasian children aged 8-10 years with at least one obese biological parent (i.e., with an overall body mass index (BMI) ≥30 kg/m² or abdominal waist circumference ≥88 cm for women or ≥102 cm for men) were included in the study. Children did not participate in the study if they: i) were currently on a very restricted low-calorie diet (≤600 kcal/day); ii) had a health problem including any psychological condition, that compromised participation in the study; iii) had type 1 or type 2 diabetes; or iv) took steroids, β-blockers, thiazides or other drugs for hypertension. Families were recruited through schools located within 75 km of Montreal, Quebec City or Sherbrooke (Canada). The baseline examination took place between 2005 and 2008. Due to missing data in 82 children (40 boys and 42 girls), 550 children (299 boys and 251 girls) were included in the current analytical sample (final sample). This project was approved by the ethics review boards at Centre Hospitalier Sainte-Justine and Laval University and written informed parental consent and child assent were obtained for all participants.

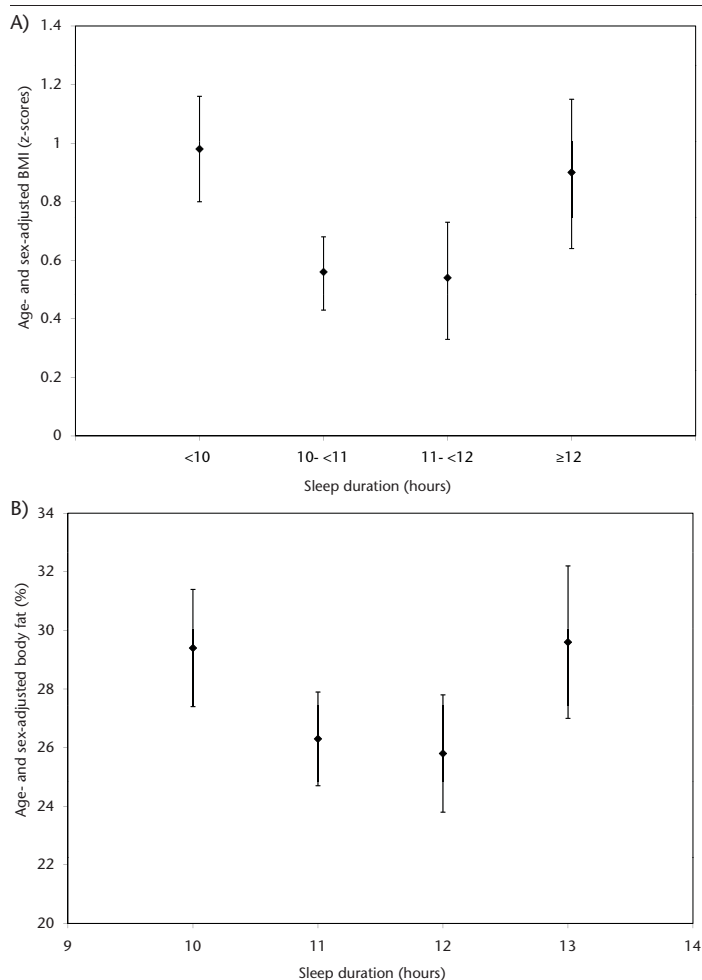
Anthropometric and body composition measurements

Height, weight and waist circumference (mid-distance between the last floating rib and the iliac crest) were measured by trained assistants, with the child wearing light clothing, per standardized methods.¹¹ Age- and sex-specific BMI percentiles were computed according to the United States Centers for Disease Control growth charts.¹² Children were categorized as overweight/obese if their BMI was ≥85th age- and sex-specific percentile. BMI Z-score was computed by subtracting the mean BMI of the sample from the individual BMI and then dividing the difference by the SD of the sample. This standard score allows comparison of observations from different normal distributions. Age- and sex-adjusted BMI Z-scores were used for statistical analysis. Body fat mass and fat mass percentage were measured by dual-energy X-ray absorptiometry (DXA; GE Prodigy Lunar, Madison, WI, USA).

Sleep duration assessment

The number of hours of sleep was assessed over a 7-day period using an Actigraph activity monitor (GT1M; Actigraph LLC, Pensacola,

Figure 1. Association of sleep duration with (A) body mass index and (B) percent body fat in Canadian children



Bars indicate 95% confidence intervals.

Note: A BMI Z-score of 1 indicates a mean of 1 SD higher than the midpoint of the reference population.

FL). Participants were instructed to wear the accelerometer on an elastic waist band on the right hip, except during bathing and other aquatic activities. Sleep time was calculated as the difference

Table 2. Dietary and Physical Activity Patterns of Children According to Sleep Duration Group

Variable	<10 hours (n=126)	10-10.9 Hours (n=262)	11-11.9 Hours (n=96)	≥12 Hours (n=66)	p-value
Diet					
Energy intake (kcal/day)	1659 ± 408	1684 ± 395	1646 ± 407	1779 ± 400	0.19
Fat intake (g/day)	59.1 ± 18.3	61.8 ± 19.2	57.6 ± 17.9	65.7 ± 16.9	0.03
Saturated fat intake (g/day)	21.2 ± 7.3	21.8 ± 7.8	20.6 ± 7.5	23.1 ± 6.5	0.19
Carbohydrate intake (g/day)	219 ± 55	220 ± 55	225 ± 63	227 ± 64	0.68
High-sugar drinks (mL/day)	133 ± 153	110 ± 131	116 ± 118	146 ± 175	0.22
Vegetables/fruits (servings/day)	3.0 ± 1.9	3.0 ± 1.5	3.0 ± 1.7	3.3 ± 1.9	0.64
Snacks (number/day)	4.7 ± 2.2	4.7 ± 2.1	4.9 ± 1.8	4.7 ± 2.1	0.94
Physical activity					
Screen time (hours/day)	3.4 ± 2.2	2.9 ± 2.1	3.2 ± 2.3	3.0 ± 2.1	0.24
LPA (min/day)	154 ± 34	159 ± 38	150 ± 35	162 ± 38	0.33
MVPA (min/day)	25.3 ± 16.8	24.7 ± 17.2	24.6 ± 17.1	27.7 ± 15.2	0.76

LPA=light physical activity; MVPA=moderate-to-vigorous physical activity.

Note: Data are presented as mean ± SD.

Statistical significance was assessed by analysis of variance.

between bedtime and wake-up time, and mean sleep duration over 7 days was computed. Sleep assessment in free-living conditions with the use of actigraphy has been shown to provide valid and reliable estimates of total sleep time.¹³ The children were categorized into 4 groups according to the mean sleep duration over 7 days: <10 hours, 10-10.9 hours, 11-11.9 hours, and ≥12 hours of sleep. Given that the sleep needs of school-aged children (5-12 years) are of 10-11 hours/night,¹⁴ it is relevant from a public health perspective to have a category of short-duration sleepers of less than 10 hours of sleep per night. The 11-11.9 hour group (i.e., the category associated with the lowest prevalence of obesity) was set as the reference category for multivariable analyses.

Covariates

Three non-consecutive 24-hour dietary recalls, including two weekdays and one weekend day, were obtained by a dietician within eight weeks of the clinic visit, as previously described.¹⁵ Foods reported on the 24-hour recalls were entered into the CANDAT software (Candat, London, ON, Canada) and converted to nutrients using the Canadian Nutrient File.¹⁶ Mean daily servings of vegetables and fruit were based on Canada's Food Guide. High sugar drinks included soft drinks and sugar-sweetened beverages. Physical activity level was assessed with an accelerometer (Actigraph LLC, Pensacola, FL) for seven consecutive days. Days on which the accelerometer was worn for less than 80% of the average time worn on the other days were excluded. Accelerometry data were downloaded in one-minute intervals and underwent standardized quality control and data reduction procedures.¹⁷ Time spent in light, moderate, and vigorous intensity physical activity was evaluated using published pediatric cut-offs for accelerometry output.¹⁸ This method of physical activity assessment has been shown to be valid and to provide reliable estimates of physical activity in this population.^{18,19} Daily screen time was computed based on the child's report of time spent watching television, playing video games or using the computer for leisure on weekdays and weekend days, and a mean score over the 7 days was used in the analyses. Sexual maturation was assessed by trained observers using the Tanner stages. Assessments were based on genitalia and pubic-hair development in boys, and breast and pubic-hair development in girls, and were ranked on a 5-point scale from stage 1 (prepubertal) to 5 (adult). Baseline questionnaires ascertained demographic information including age, sex, highest educational level of the parents (high school, pre-university level [CEGEP for Quebec], university), and

total annual family income (categorized into 12 groups ranging from <\$10,000 to ≥\$140,000). Parental obesity (BMI ≥30 kg/m² in either parent, based on measured height and weight) was tested in the analyses as a potential confounding variable.

Statistical analysis

Since there was no statistically significant interaction between sleep and gender, data for both sexes were combined to improve clarity and maximize power. Differences in demographic, anthropometric, dietary and physical activity characteristics by sleep duration categories were assessed in analysis of variance (continuous variables) and chi-squared test (categorical variables). Post-hoc tests with Bonferroni corrections were conducted to investigate which of the different sleep duration groups differed from the others. We conducted logistic regression analyses to determine the influence of covariates (age, sex, Tanner stage, highest educational level of the parents, total annual family income, and parental BMI) and potential mediators (total caloric intake and moderate-to-vigorous physical activity) on the association between sleep duration and overweight/obesity. Variance inflation factors were <2.5, suggesting that multicollinearity was not a problem in the present analyses.²⁰ Odds ratios (OR) and 95% confidence intervals (95% CI) for the prevalence of overweight/obesity were calculated. A 2-tailed p-value of less than 0.05 was considered to indicate statistical significance. All statistical analyses were performed using the JMP version 8 program (SAS Institute, Cary, NC, USA).

RESULTS

Table 1 presents characteristics of children by sleep duration category. The mean sleep duration was 10.8 (SD=1.4) hours per night. Short-duration sleepers were significantly older than children in the two intermediate categories (p<0.05). No significant differences between the four sleep duration categories were detected by sex or socio-economic status.

There was a U-shaped relationship between sleep duration and BMI Z-score (p<0.001; Figure 1A) as well as percent body fat (p<0.001; Figure 1B). Children with the shortest (<10 hours) and longest (≥12 hours) sleep duration had higher BMIs (p<0.01) than children with intermediate sleep durations. Similarly U-shaped associations were observed between sleep duration and each of body weight and waist circumference (Table 1). Short-duration sleepers (<10 hours) had higher body weight and abdominal circumference values than children with intermediate sleep durations

Table 3. Unadjusted and Adjusted Odds Ratios for Overweight/Obesity

	Sleep duration group							
	<10 Hours (n=126)		10-10.9 Hours (n=262)		11-11.9 Hours (n=96)		≥12 Hours (n=66)	
	OR	95% CI	OR	95% CI	Reference	OR	95% CI	
Model 1 (unadjusted)	2.20	1.27-3.80	1.11	0.68-1.82	1.00	1.57	0.83-2.98	
Model 2 (+ confounders)	2.08	1.16-3.67	1.08	0.67-1.80	1.00	1.52	0.80-2.94	
Model 3 (+ mediators)	2.05	1.15-3.63	1.07	0.67-1.79	1.00	1.50	0.79-2.93	

OR, odds ratio; CI, confidence interval.

Note: Overweight/obesity was defined as a BMI ≥85th age- and sex-specific percentile.

Model 1: unadjusted OR.

Model 2: adjusted for age, sex, Tanner stage, highest educational level of the parents, total annual family income, and parental BMI.

Model 3: adjusted for total caloric intake and moderate-to-vigorous physical activity in addition to age, sex, Tanner stage, highest educational level of the parents, total annual family income, and parental BMI.

($p < 0.05$). However, long-duration sleepers (≥ 12 hours) had significantly higher body weight and waist circumference values only when compared to the 11-11.9 hour sleeping group ($p < 0.05$).

To further understand the U-shaped associations observed between sleep duration and the adiposity indices, we examined the dietary and physical activity characteristics of children according to sleep duration category (Table 2). Only dietary fat intake was significantly associated with sleep duration category. Post-hoc analysis revealed that fat intake was significantly greater in long-duration sleepers than in those whose sleep duration was 11-11.9 hours ($p < 0.05$). Of interest, results were not materially different when only weekdays (5 school days) were included in the analyses or with the use of tertiles/quartiles of sleep duration.

The influence of covariates on the relationship between sleep duration and overweight/obesity is presented in Table 3. Unadjusted logistic regression showed a significant increase in the odds of being overweight/obese with ≤ 10 hours of sleep per night (OR 2.20, 95% CI 1.27-3.80) compared to those sleeping between 11 and 12 hours. After adjusting for age, sex, Tanner stage, highest educational level of the parents, total annual family income, and parental BMI, short sleep duration was still associated with an increased odds of being overweight/obese (OR 2.08, 95% CI 1.16-3.67). Similar results were observed after adjustment for total energy intake and moderate-to-vigorous physical activity in addition to covariates (OR 2.05, 95% CI 1.15-3.63). Further adjustments for other diet and/or sedentary behaviours (e.g., high-sugar drinks and screen time) did not attenuate the coefficient.

DISCUSSION

This study showed a U-shaped association between sleep duration and adiposity indices in a large sample of children studied in their natural environment. However, only short sleep duration (< 10 hours/night) was independently associated with an increased risk of overweight/obesity after adjustment for covariates. The key finding is that total caloric intake and moderate-to-vigorous physical activity did not explain the short sleep-obesity connection. This finding is somewhat surprising given that increased energy intake and/or reduced physical exercise are thought to be the mediators of this association.

Short sleep duration appears to be a novel and independent risk factor for obesity.²¹ Recent results have shown that short sleep duration was the most important risk factor for overweight and obesity in a cohort of children aged 5-10 years.²² Indeed, excess body weight was predicted by short sleep duration, with odds ratios exceeding those of other well-known risk factors including parental obesity, television viewing, socio-economic status, and physical

inactivity. Likewise, short sleep duration has been reported to contribute more importantly to overweight/obesity and weight gain than other well-established risk factors such as non-participation in high-intensity physical exercise and high dietary fat intake in a cohort of adults.²³ The mounting body of epidemiological evidence associates the lack of sleep not only with obesity,²⁴ but also with type 2 diabetes,²⁵ coronary heart disease,²⁶ hypertension,²⁷ and all-cause mortality.²⁸ The issue of short sleep duration is of high importance, because 23% of the children in the present study did not get the recommended 10-11 hours of sleep per night for school-aged children.¹⁴

Increased energy intake is currently considered the most plausible explanation as to why short-duration sleepers have a higher risk of becoming obese. This concept is supported by recent intervention studies showing that sleep restriction increased intake of calories from snacks²⁹ and overall energy intake³ in adults. Furthermore, results from a recent cross-sectional study in adolescents showed that shorter sleep duration was associated with a relatively higher caloric intake derived from fat and a twofold increased risk of consuming ≥ 475 kcal/day from snacks.³⁰ In contrast, our study failed to associate short sleep duration with dietary patterns that might promote a positive energy balance. Despite this, short sleep duration was independently associated with overweight/obesity in our study. Some studies in adults have also failed to show an attenuation of the association between short sleep duration and overweight/obesity after adjustment for diet and physical activity.⁸⁻¹⁰ This might be explained by reporting bias or the imprecision of the measure even when using 24-hour diet recalls, which is the gold standard to assess diet in epidemiological studies. Small chronic energy differences associated with short sleep duration might be difficult to capture in dietary recalls; thus, we do not exclude increased food intake as a possible explanation.

On the other side of the energy balance equation, reduced energy expenditure may also contribute to the association between sleep duration and overweight/obesity. The increased fatigue associated with lack of sleep generally decreases motivation to exercise. In particular, recent results have shown that short-term sleep restriction (2 nights of 4 hours in bed) was accompanied by a decrease in daytime spontaneous physical activity in healthy men.³¹ Interestingly, the reduction in overall physical activity was explained by a shift toward less intense activities under free-living conditions. Here again, our results failed to show an association between physical activity and short sleep duration, including total screen time. This observation should be regarded as robust because we have used an objective measure of physical activity over 7 days. Reductions in non-exercise activity thermogenesis (NEAT) may be

another mechanism by which lack of sleep influences energy expenditure. Future research should measure NEAT levels in relation to lack of sleep in order to improve our understanding of the contribution of this energy expenditure component.

Strengths of this study include objectively measured adiposity indices as well as physical activity in a community-based sample of children studied in their natural environment. Additionally, we had detailed dietary data that enabled us to analyze the association between sleep duration and specific dietary variables. Another strength of this study is that sleep duration and physical activity were both measured every day for 7 consecutive days. Among the limitations of this study is its cross-sectional nature, which does not permit causal inferences. Moreover, there are the common limitations associated with self-reported measures (i.e., screen time and diet assessment), including the potential for under-reporting. To maximize reliability, we have administered the 24-hour food recalls over 3 days. However, dietary measures in naturalistic sleep studies are difficult to interpret as they are not sensitive enough to be independent predictors. Increased energy intake could still be an important explanation of the short sleep–obesity link, but current tools cannot confirm this possibility in epidemiological studies. Finally, the external generalizability of our findings may be restricted to children of Western European descent with a parental history of obesity.

In summary, the present study provides evidence that short sleep duration is a risk factor for overweight and obesity in children, independent of potential covariates. Furthermore, our results showed that total caloric intake and moderate-to-vigorous physical activity did not explain the short sleep–obesity association. Given that dietary recalls are generally imprecise, especially in relation to obesity, the finding that the short sleep–obesity link is independent of energy intake might be due to measurement error. Before recommendations can be made, future studies should put efforts toward elucidating the entire pathway from sleep curtailment through obesity development.

REFERENCES

- Nielsen LS, Danielsen KV, Sørensen TI. Short sleep duration as a possible cause of obesity: Critical analysis of the epidemiological evidence. *Obes Rev* 2011;12:78-92.
- Patel SR. Reduced sleep as an obesity risk factor. *Obes Rev* 2009;10(Suppl 2):61-68.
- Brondel L, Romer MA, Nougues PM, Touyarou P, Davenne D. Acute partial sleep deprivation increases food intake in healthy men. *Am J Clin Nutr* 2010;91:1550-59.
- Spiegel K, Tasali E, Leproult R, Van Cauter E. Effects of poor and short sleep on glucose metabolism and obesity risk. *Nat Rev Endocrinol* 2009;5:253-61.
- Spiegel K, Tasali E, Penev P, Van Cauter E. Brief communication: Sleep curtailment in healthy young men is associated with decreased leptin levels, elevated ghrelin levels, and increased hunger and appetite. *Ann Intern Med* 2004;141:846-50.
- Chaput JP. Short sleep duration promoting overconsumption of food: A reward-driven eating behavior? *Sleep* 2010;33:1135-36.
- Chaput JP, Klingenberg L, Astrup A, Sjödin AM. Modern sedentary activities promote overconsumption of food in our current obesogenic environment. *Obes Rev* 2011;12:e12-20.
- Nishiura C, Noguchi J, Hashimoto H. Dietary patterns only partially explain the effect of short sleep duration on the incidence of obesity. *Sleep* 2010;33:753-57.
- Patel SR, Malhotra A, White DR, Gottlieb DJ, Hu FB. Association between reduced sleep and weight gain in women. *Am J Epidemiol* 2006;164:947-54.
- Chaput JP, Després JP, Bouchard C, Tremblay A. The association between sleep duration and weight gain in adults: A 6-year prospective study from the Quebec Family Study. *Sleep* 2008;31:517-23.
- The Airlie (VA) Consensus Conference. In: Lohman TG, Roche AF, Martorell R (Eds.), *Standardization of Anthropometric Measurements*. Champaign, IL: Human Kinetics Publishers, 1988;39-80.

- Centers for Disease Control. Growth chart training. 2000. Available at: <http://www.cdc.gov/nccdphp/dnpa/growthcharts/index.htm> (Accessed May 2011).
- Sadeh A. The role and validity of actigraphy in sleep medicine: An update. *Sleep Med Rev* 2011;15:259-67.
- National Sleep Foundation. How much sleep do we really need? Available at: <http://www.sleepfoundation.org/article/how-sleep-works/how-much-sleep-do-we-really-need> (Accessed May 2011).
- Obarzanek E, Kimm SY, Barton BA, Van Horn LL, Kwitrovich PO Jr, Simons-Morton DG, et al. Long-term safety and efficacy of a cholesterol-lowering diet in children with elevated low-density lipoprotein cholesterol: Seven-year results of the Dietary Intervention Study in Children (DISC). *Pediatrics* 2001;107:256-64.
- The Canadian Nutrient File. Health and Welfare Canada, 2007.
- Colley R, Gorber SC, Tremblay MS. Quality control and data reduction procedures for accelerometry-derived measures of physical activity. *Health Rep* 2010;21:63-69.
- Puyau MR, Adolph AL, Vohra FA, Butte NF. Validation and calibration of physical activity monitors in children. *Obes Res* 2002;10:150-57.
- Esliger DW, Tremblay MS. Technical reliability assessment of three accelerometer models in a mechanical setup. *Med Sci Sports Exerc* 2006;38:2173-81.
- Allison PD. Logistic regression using SAS – Theory and application. SAS Institute and Wiley, 2001.
- Chaput JP, Klingenberg L, Sjödin AM. Do all sedentary activities lead to weight gain: Sleep does not. *Curr Opin Clin Nutr Metab Care* 2010;13:601-7.
- Chaput JP, Brunet M, Tremblay A. Relationship between short sleeping hours and childhood overweight/obesity: Results from the “Québec en Forme” Project. *Int J Obes* 2006;30:1080-85.
- Chaput JP, Leblanc C, Pérusse L, Després JP, Bouchard C, Tremblay A. Risk factors for adult overweight and obesity in the Quebec Family Study: Have we been barking up the wrong tree? *Obesity* 2009;17:1964-70.
- 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;5:214-20.
- Chaput JP, Després JP, Bouchard C, Astrup A, Tremblay A. Sleep duration as a risk factor for the development of type 2 diabetes or impaired glucose tolerance: Analyses of the Quebec Family Study. *Sleep Med* 2009;10:919-24.
- King CR, Knutson KL, Rathouz PJ, Sidney S, Liu K, Lauderdale DS. Short sleep duration and incident coronary artery calcification. *JAMA* 2008;300:2859-66.
- Knutson KL, Van Cauter E, Rathouz P, Yan LL, Hulley SB, Liu K, et al. Association between sleep and blood pressure in midlife: The CARDIA Sleep Study. *Arch Intern Med* 2009;169:1055-61.
- Galliechio L, Kalesan B. Sleep duration and mortality: A systematic review and meta-analysis. *J Sleep Res* 2009;18:148-58.
- Nedeltcheva AV, Kilkus JM, Imperial J, Kasza K, Schoeller DA, Penev PD. Sleep curtailment is accompanied by increased intake of calories from snacks. *Am J Clin Nutr* 2009;89:126-33.
- Weiss A, Xu F, Storfer-Isser A, Thomas A, Ievers-Landis CE, Redline S. The association of sleep duration with adolescents' fat and carbohydrate consumption. *Sleep* 2010;33:1201-9.
- Schmid SM, Hallschmid M, Jauch-Chara K, Wilms B, Benedict C, Lehnert H, et al. Short-term sleep loss decreases physical activity under free-living conditions but does not increase food intake under time-deprived laboratory conditions in healthy men. *Am J Clin Nutr* 2009;90:1476-82.

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RÉSUMÉ

Objectif : Cette étude avait pour but d'investiguer la relation entre la durée du sommeil et les indices d'adiposité et de déterminer si l'apport calorique et la pratique d'activité physique sont des médiateurs de cette relation.

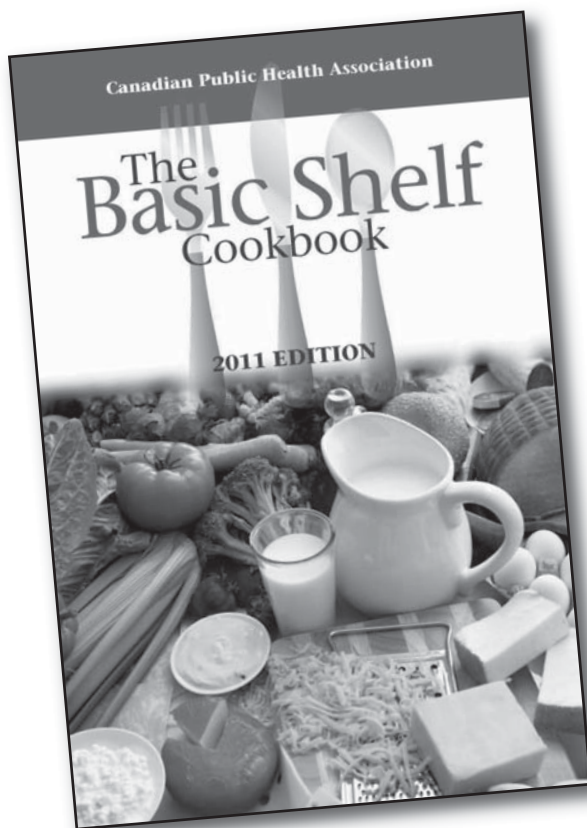
Méthodologie : L'étude *QUALITY (Quebec Adiposity and Lifestyle Investigation in Youth)* est une étude longitudinale chez des enfants caucasiens qui ont au moins un parent biologique obèse. Les enfants (n=550) avec une moyenne d'âge de 9,6 ans (déviations standard : 0.9 ans) et chez qui des données complètes ont été obtenues ont été inclus dans les analyses transversales. Des mesures objectives d'adiposité (score Z d'indice de masse corporelle, circonférence de la taille et pourcentage de gras mesuré par absorption bi-photonique à rayons X), du temps de sommeil et d'activité physique (accéléromètre sur une période de 7 jours) et de la diète (rappels alimentaires de 24 heures) ont été collectées. Les enfants ont été catégorisés dans 4 groupes selon leur durée de sommeil : <10 heures, 10-10.9 heures, 11-11.9 heures et ≥12 heures de sommeil par nuit.

SLEEP DURATION AND OBESITY

Résultats : Nous avons observé une relation en forme de U entre la durée du sommeil et tous les indices d'adiposité. L'apport énergétique, le nombre de collations, le temps devant l'écran et l'intensité de l'activité physique ne différaient pas de façon significative entre les catégories de sommeil. Après ajustement pour l'âge, le sexe, les stades de Tanner, le niveau d'éducation des parents, le revenu annuel total des parents et l'indice de masse corporelle des parents, seulement les petits dormeurs (<10 heures) avaient un risque accru d'être en surpoids ou obèse (rapport des cotes (RC) 2.08, intervalle de confiance à 95% 1,16-3,67). L'addition de l'apport énergétique total et de la pratique d'activité physique au modèle statistique n'a pas changé l'association de façon importante (RC 2,05, IC 95% 1,15-3,63).

Conclusion : La présente étude montre qu'une courte durée de sommeil est un facteur de risque de surpoids et d'obésité chez les enfants, indépendamment des variables confondantes potentielles. Ces résultats renforcent le besoin d'ajouter la durée du sommeil dans la liste des déterminants de l'obésité.

Mots clés : adiposité; indice de masse corporelle; poids corporel; enfants; balance énergétique; manque de sommeil; restriction du sommeil



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