Time in Bed and Low Body Mass Index (BMI) Among Adolescents in China

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Study Objective: To investigate the association between time in bed and low Body Mass Index (BMI <18.5 kg/m^2) among adolescents.
Methods: This is a population school-based health survey utilising a two-stage random cluster sampling design. One thousand two hundred and sixty seven (n=1267) subjects aged 13 to17 years participated in the study. They were recruited from the total population of adolescents attending high school in the Nanning, the capital city of the Guangxi Province, China. Time in bed was measured by self-reported time to bed and rise in a normal school week. Body Mass Index was calculated from body weight and height assessed by health professionals.
Results: There was a significant dose-response relationship between time in bed and low BMI. After adjusting for the potential confounding factors, young people who were in bed for a shorter period of time (<7 hours) had a reduced risk of about 30% for low BMI (OR= 0.76, 95%C.I.=0.58-0.99) compared to those who were in bed 7-8 hours. No significant increase in risk were found for those who slept for longer than 8 hours (OR=1.42, 95%C.I.=0.93-2.19) when compared with the controls.
Conclusions: Time in bed is associated with low BMI among adolescents suggesting a potential link to chronic energy deficiency (CED). It would be prudent for clinicians to include the assessment of potential CED in the evaluation and diagnosis of sleep-related problems among adolescents. **(Sleep and Hypnosis 2008;10(1):11-18)**

Key words: Time in bed, low BMI, chronic energy deficiency, adolescents, China

INTRODUCTION

Time in bed as a health issue has not received much attention until recently. With rapid developments in sleep medicine, there has been a growing interest in the effect of insufficient or inadequate sleep, in terms of the time in bed, on physical and psychological health (1). There is a growing wealth of evidence for the association between time in bed and major health problems mainly among adults including all-cause mortality; breast cancer; diabetes; Parkinson disease; hypertension; and obesity (1-10).

Recent studies have identified that time in bed plays an important role in affecting body weight in both adults and young children (11-17). In an earlier study among Spanish adults, it was found that obesity was associated with various lifestyle variables including spending more time watching TV, less sleeping time, and less physical activity at

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work. It was reported that adults who slept for nine hours or more had a reduced risk of being obese when compared with those who slept six hours or less with a odds ratio of 0.43 (95%C.I.=0.27-0.67) (11). A similar phenomenon was also observed among young children in other parts of the world. In a longitudinal birth cohort study among young Japanese children aged 6-7 years, a dose-response relationship was demonstrated between short sleep hours and childhood obesity. There were progressive increases in the odds of obesity for children who slept for 9-10 hours, 8-9 hours, and less than 8 hours as compared with those who slept more than 10 hours with odds ratios of 1.49, 1.89, and 2.87 respectively after controlling for other confounding factors such as parental obesity and physical inactivity (12). Similar results were also obtained from even younger children aged 5-6 years old in Germany (13). In the most recent study in Quebec in Canada, a similar dose-response relationship between time in bed and the risk of obesity and overweight was also shown among young children aged between 5 and 10 years (17).

It is understandable that most research attention has been focused on the relationship between time in bed and obesity and overweight, as conventionally assessed by high Body Mass Index (BMI), given that obesity is an increasing health problem among children and adolescents in most developed countries and more recently in developing countries (18). Furthermore, obesity has been identified as a risk factor for many physical conditions among children and adolescents. These include cardiomyopathy, pancreatitis, orthopaedic disorders, and some respiratory disorders (19-20). While there have been increasing evidence for the association between short duration of sleep and obesity, the relationship between time in bed and the other end of the BMI spectrum (i.e. low BMI), particularly with BMI < 18.5 kg/m^2 which has been suggested as a potential indicator of chronic energy deficiency (CED) (21), there has not been equivalent attention. In fact, no study has been found in the current literature.

The aim of this study is to examine the relationship between time in bed and low BMI among a population of adolescents in the South Western part of China.

METHODS

This study was a population-based health survey utilising a two-stage random cluster sampling design. The study was conducted in Nanning city of the Guangxi Province in South Western China in March 2005. Nanning, the capital city of the Guangxi Province, is the biggest and most populated city of the Province with an estimated population of about 1.4 million in 2001. The population size for young adolescents aged between 15 and 19 years was estimated to be 199,605. This represented about 15% of the total population in the city. Institute ethics approval for the study was granted by the Ethics Committee of the Guangxi Medical University.

The sample frame of the study was the total population of adolescents who attended high school years 1, 2, and 3 with ages ranging from 13 years to 17 years. There were in total 85 high schools in the Nanning city with an average of 5 classes in each year and about 50 students in each class. Hence, there were more than 60,000 young adolescents in the sample frame. Students who attended special schools due to specific physical or mental disabilities were excluded from the study.

The sampling of students consisted of a two-stage process with stratification according to high school years. First, using individual schools as the primary sampling unit, a number of schools were randomly selected with a probability which is proportional to the size of the target population in each school. Second, using the class as the secondary sampling unit, different clusters of students were randomly selected from each of the selected schools. The sample size estimation was conducted with an assumption of a low to moderate correlation of 0.2 and the standard deviation of the outcome variable being 1.5 times of the predictor variable with a 5% significant level and 80% of study power. Further assumptions were made on the cluster samples having an intraclass correlation of 0.02 for BMI, and an average cluster size of 50 students. Hence, according to Kish, the effect of cluster sample design (deff) was calculated as deff=1+(intraclass correlation)*(cluster size-1)=1.98 (22). The estimated sample size for the cluster sample was the estimated sample size for a simple sample multiplied by the effect of cluster sample design. Based on the above assumptions, the required sample size was estimated to be about 1200.

The health survey was conducted using a two-prone approach, a self-reported questionnaire survey and a personal interview. All high schools in the Nanning city are government schools under the auspices of the Education Department of the Provincial Government. The health care of all high school students is provided by the in-house health care centre at each school, mainly by a resident medical doctor. Hence, important information on the health status of these students could be obtained directly from the resident medical doctor of each school. In this study, medical doctors from the selected schools were recruited, with the involvement of the Education Department, to provide assessment on students' health. These assessments included anthropometric measures such as body weight and height. The BMI of each student was then calculated. The primary outcome of the study, low BMI, was defined as a BMI less than 18.5 kg/m^2 adopting the above-mentioned concept of a cut-off point for a potential classification of chronic energy deficiency.

Sleep information, including time in bed and snoring, was collected using a self-reported questionnaire. Students were asked to indicate the usual clock hour for bed and the usual clock hour for rise during normal week days. The time in bed during normal week days was calculated from these times. Other information including demographics, such as parental education levels, family structure and income, number of siblings, and the duration of physical activity involvement per week was also collected. Psychological distress was assessed by self-report using a distress assessment scale modified from the Minnesota adolescent health survey. As the study was considered as an official activity of the Education Department of the Provincial Government, all selected students participating in the study and were interviewed with 100% cooperation.

Data were analysed using the Stata statistical software program (23). Since the study was of a cluster sampling design, data were set up with the survey design function utilising the svy commands for handling the cluster sampling effect. In this study the outcome of low BMI, defined as BMI <18.5 kg/m^2, was compared to the normal BMI group (18.5-25.0 kg/m^2). Hence the outcome variable was treated as a binary variable. Time in bed was also treated as a categorical variable and classified into <7 hours, 7-8 hours, and 8 hours or more. This categorisation of the time in bed was in line with the literature. Bivariate analyses were conducted to examine unadjusted relationships between all variables of interest and the outcome variable. Chi-square tests were applied for testing the significance of association. All statistical tests of hypothesis were adjusted for the cluster sampling design. Data were further analysed using logistic regression modelling to examine the relationship between low BMI and the time in bed, after adjusting for potential confounding factors identified in the bivariate analyses. For the inclusion of any variable in the linear regression model, the criteria of a bivariate association with $p<0.05$ was used.

RESULTS

A cluster random sample was obtained from 9 different schools and 24 different classes, resulting in a total of 1267 students with their BMI less than 25.0 kg/m^2. The characteristics of these students were summarised in Table 1. The sample consisted mainly of adolescents aged between 14 and 15 years old (n=737, 61.8%) with a mean age of 14.6 years (S.E.=0.1) with nearly an even distribution between males (50.8%) and females. In terms of socioeconomic indictors, there was also a nearly even distribution of the fathers' education levels among these adolescents, with slightly more mothers who had received a level of education at junior high school level or lower (41.5%). About eleven percent (n=139, 11.3%) of these adolescents came from better off families with a high total family income, 27.9% with an average income, and more than half (n=733, 60.8%) came from poorer families with a low income. The majority (n=1158, 91.6%) of these adolescents lived in an intact family environment with both parents, whereas the rest lived with only one parent due to death or divorce. Most of these adolescents are the single child of the family (n=774, 61.2%). Half of these young people had regular weekly exercise with 6 or more hours (n=603, 49.4%) and about eleven percent (n=145, 11.1%) scored higher than the third quartile of the total sample on the psychological distress score.

In terms of the outcome variable, slightly more than half (n=703, 55.5%) of the sample were classified as having low BMI (BMI< 18.5 kg/m^2). The mean time in bed was 7.6 hours (S.E.=0.1) with 141 (10.3%) reported to have slept less than 7 hours per night, 930 (74.0%) slept 7-8 hours, and 15.7% (n=189) slept longer than 8 hours per night during a normal school week. About 10% (n=133, 10.4%) reported to have been told they snored while sleeping.

The bivariate relationships between low BMI, time in bed, demographics, and other variables were examined. The results were also summarised in Table 1. As shown, there was a significant unadjusted association between time in bed and low BMI among these adolescents (p=0.004). This was supported by the results obtained from the odd ratios calculation exhibiting an unadjusted dose-response relationship between time in bed and the relative risk of low BMI. There was a significantly reduced unadjusted odds of low BMI (OR=0.66, 95%C.I.=0.50-0.88) for those who were in bed less than 7 hours and a significantly increased odds (OR=1.68, 95%C.I.=1.07-2.64) for those who slept more than 8 hours when compared with those who slept 7-8 hours per night. In terms of demographics and other variables, significant associations were also found between snoring, father's education level, mother's education level, income, number of siblings, psychological distress, and low BMI. (Table 1) Due to the fact that parental education levels and family income were highly correlated, this might constitute collinearity problems in the logistic regression procedures. Hence, the most significant variables among the three, namely mother's education level and other significant variables were selected to be included in the logistic regression modelling.

The results obtained from the linear regression analyses were presented in Table 2. On the whole they were similar to that obtained in the bivariate analyses. As shown, after adjusting for the potential confounding factors, there was still a significant association between time in bed and low BMI among these adolescent, particularly for those who slept less than 7 hours with an

Table 1. Frequency distribution and percentages of time in bed, demographic and other variables by low BMI status (N=1267)

	Low BMI (< 18.5 kg/m^2)		Total*	Test for association#
	Yes (n=703)	No (n=564)		
Sleep variables				
Time in bed				
< 7 hours	63 (8.3)**	78 (12.9)	141 (10.3)	_2 2=17.26,
7-8 hours	509 (72.7)	421 (75.4)	930 (74.0)	p=0.004
more than 8 hours	127 (19.0)	62 (11.7)	189 (15.7)	
Snore				
Yes	62 (8.8)	71 (12.4)	133 (10.4)	_2 1=4.20,
No	637 (91.2)	490 (87.6)	1127 (89.6)	p=0.026
Demographic variables				
Age				
<14 years	226 (33.3)	147 (27.3)	373 (30.6)	_2 2=5.37,
14-15 years	414 (59.6)	359 (64.5)	773 (61.8)	p=0.145
16 years or older	58 (7.1)	53 (8.2)	111 (7.6)	
Sex				
Male	363 (51.7)	279 (49.7)	642 (50.8)	_2 1=0.48,
Female	338 (48.3)	283 (50.3)	621 (49.2)	p=0.607
Father's education level				
University/Prof. Certificate	194 (28.4)	208 (38.5)	402 (32.9)	_2 2=14.52,
High School/Technical Cert.	243 (35.3)	175 (31.8)	418 (33.7)	p=0.012
Junior high school or lower	242 (36.3)	161 (29.7)	403 (33.4)	
Mother's education level				
University/Prof. Certificate	150 (21.6)	173 (31.7)	323 (26.1)	_2 2=27.75,
High School/Technical Cert.	216 (30.7)	192 (34.5)	408 (32.4)	p<0.001
Junior high school or lower	322 (47.7)	191 (33.8)	513 (41.5)	
Family total income***				
High	58 (8.6)	81 (14.7)	139 (11.3)	_2 2=11.41,
Average	193 (28.7)	147 (26.9)	340 (27.9)	p=0.039
Low	417 (62.7)	316 (58.4)	733 (60.8)	
Family structure				
Intact	642 (91.6)	516 (91.7)	1158 (91.6)	_2 1=0.01,
Single parent/divorced	59 (8.4)	46 (8.3)	105 (8.4)	p=0.906
Number of sibling				
Single child	391 (55.5)	383 (68.3)	774 (61.2)	_2 1=21.80,
Have siblings	312 (44.5)	181 (31.7)	493 (38.8)	p<0.001
Other variables				
Physical activity/week				
6 hours or more	347 (49.7)	290 (51.6)	637 (50.6)	_2 1=0.43,
<6 hours	356 (50.3)	274 (48.4)	630 (49.4)	p=0.471
Psychological distress				
Yes	67 (9.3)	78 (13.4)	145 (11.1)	_2 1=5.34,
No	631 (90.7)	483 (86.6)	1114 (88.9)	p=0.035

*Not necessarily adding up to the total due to missing data; **Percentages were adjusted for the effect of cluster sampling;
*** High=>RMB$4000, Average=RMB$2000-4000, Low=less than RMB$2000; # Test statistic adjusted for the effect of cluster sampling

Table 2. Unadjusted and adjusted Odds Ratios and 95% confidence intervals for low BMI of various time in bed

	OR (95%C.I.)	
	Unadjusted	Adjusted**
Time in bed		
< 7 hours	0.66 (0.50-0.88)	0.76 (0.58-0.99)
7-8 hours*	1.00	1.00
more than 8 hours	1.68 (1.07-2.64)	1.42 (0.93-2.19)

* Referent Group; ** Calculation adjusted for mother's education level, number of sibling, psychological distress, and snoring.

adjusted odds of 0.76 (95%C.I.=0.58-0.99) when compared with those who slept 7-8 hours. However, the association between longer time in bed (>8 hours) and low BMI became marginally insignificant after adjusting for potential confounders (OR=1.42, 95%C.I.=0.93-2.19). In terms of the risk pattern, the dose-response relationship between time in bed and low BMI, by and large, remained. Further analyses indicated that none of the interaction terms between time in bed and other variables included were significant suggesting that time in bed had an independent effect on low BMI.

DISCUSSION

This study attempts to study the relationship between time in bed and low BMI among adolescents in China. To the knowledge of the authors, it is the first study ever conducted which examines the issue of time in bed and low BMI among adolescents. The results obtained suggest, after adjusting for potential confounding factors including socioeconomic status and snoring as an indicator of sleep problems, that time in bed is positively associated with a low BMI less than 18.5 kg/m^2. These results provide support that time in bed can be considered as an independent risk factor for low BMI. The risk pattern suggests a potentially dose-response relationship between time in bed and low BMI with the risk of low BMI increasing as the length of time in bed increases. Due to the lack of other similar studies in the literature, comparisons of results are difficult.

There could be many different reasons for the association between time in bed and the BMI among adolescents. The most intuitive one is a potential biological linkage between body weight and sleep. This possible explanation is related to the physiology of the human endocrine activities particularly the neuroendocrine control of appetite and the protein Leptin which is a hormone with important effects in regulating body weight, metabolism, and reproductive function. The key role of Leptin in regulating bodyweight has been long been established, where a reduction in the serum level of Leptin is associated with an increase of bodyweight and the risk of obesity (24). A recent study has also found that there is a positive relationship between Leptin levels and duration of sleep in humans, where a shortened sleep duration significantly reduces Leptin levels (25). This provides a possible physiological basis for the results obtained on the association between time in bed and the low BMI among adolescents in this study although time in bed does not equate actual duration of sleep. As the time in bed decreases, one could possibly assume that the duration of sleep also decreases, so does the serum level of Leptin and hence the body weight increases. This might explain why there is a reduction in the risk of low BMI among those who sleep for shorter durations and an increase in risk for those sleep longer. Another possible explanation lies in the social environment which provides adolescents with the reasons for going to bed late. It has been established that short time in bed is significantly associated with television watching, playing computer games, and surfing the internet among adolescents (26). As all these activities are entertainment activities, it is likely that they are also associated with some unhealthy food consumption behaviours. This is particularly true for television viewing as a positive relationship has been shown between lengthy television watching and unhealthy food habits among young people in different countries (27). Results indicate that those who watched more TV are more likely to consume sweets and soft drinks on a daily basis (27). Hence, a shorter time in bed in this sense, could be considered as one element of a cluster of unhealthy behaviours among adolescents. All these elements contribute, either independently or synergistically, to an increase in the BMI. For those adolescents who tend to be underweight at the start, this phenomenon supposing to be detrimental to adolescence health seems to have benefited them by increasing their BMI from a sub-normal to a normal level.

The results obtained from this study have a direct clinical implication. As above-mentioned, low BMI (<18.5 kg/m^2) has been suggested as an indictor of Chronic Energy Deficiency (CED). As the results in this study suggest that prolonged sleep is potentially associated with low BMI, thus by association, there is an implied increased risk of CED. This may be due to the reason that adolescents who are suffering from CED require more sleep as a bodily compensation mechanism. Hence, it would be prudent to include the assessment of CED in evaluating potential sleep problems among adolescents.

As in all studies, there are strengths and weaknesses in this study. This study utilised a two-stage random cluster sampling design. This study design takes into consideration the potential effect of the cluster samples, where there might be correlations in the important variables under study among the members within each cluster. In view of the current study, due to the multiple casual factors of low BMI, it is unlikely that there is a higher correlation in the outcome variable. Hence, a low intraclass correlation was assumed in the sample size calculation. Random sampling used in this study has provided greater confidence that the sample is representative of the population under study. The use of a standard protocol and training for all medical doctors involved in the study in collating anthropometric measures have further minimised biases in data collection. Some potential limitations have been identified in this study. First, as mentioned above, time in bed does not equate duration of sleep because no inforamtion was obtained on sleep onset latency, waking up after sleep onset, and other varibales that may affact the actual duration of sleep such as early morning awakening. Hence, time in bed as measured in this study could only be considered as an estimation of length of time staying in bed. Second, information on the exposure variables was collected via a self-report questionnaire, and it is subjected to recall or report biases. One may argue that given the benign nature of the health survey, the fact that the questions are non-threatening, and the duration for recall only covers a period of a normal week, recall error should be considered as minimal, thus recall biases would be minimised. Third, assessment errors may also occur in the anthropometric measurements due to the usage of different measuring instruments at different schools. However, with modern digitalised scales for body height and weight, assessment errors due to instrumental inaccuracy would also be minimal. Fourth, some important potential confounding variables are not assessed and thus not included in the final analyses to be controlled for. These variables include parental bodyweight or BMI, other non-physical activities such as television viewing, electronic game playing, internet surfing, as well as food consumption patterns, particularly snacks and soft drinks. For further study, these variables should be included as part of the data collection. Finally, due to the fact that the study is a cross-sectional survey, the results obtained provide no supportive evidence for causality. Hence it could also be possible that low BMI is the etiological factor for sleep problems.

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