

# Association between sleep duration and body-mass-index in 10- to 14-year-old Austrians

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## Summary

This cross-sectional study (n = 301) was designed to analyze the association between sleep duration and body mass index in 10- to 14-year-old Austrians. A significant correlation between sleep duration and BMI was detected in the study population. In a gender-specific analysis, male children were found to be at higher risk to develop overweight/obesity when their sleep duration was decreased (n = 109; Odds Ratio [OR] 6.1; p = 0.033); independently of country of birth and type of school. This correlation was not found for girls.

The evaluation of children's ideal sleep duration would be helpful in generating consistent (sleep) recommendations which could be integrated into existing prevention programs as an additional tool to avoid overweight and obesity. The results highlight the need for a more comprehensive and representative analysis focusing on obesity and sleep duration, particularly in male children.

**Keywords:** children, adolescents, sleep duration, obesity, overweight

well as in children (particularly those under 10 years of age) demonstrate that insufficient sleep duration is associated with overweight and obesity. There appears to be a stronger tendency towards obesity in the event of shortened sleep duration for boys than girls [5, 7]. There are also potential indications that insufficient sleep duration in childhood has an effect on later body composition [8].

The aim of the study was to analyze the association between sleep duration and BMI in an age group where studies carried out to date have not proven informative and results have not been conclusive.

## Introduction

Obesity is increasing in all industrial nations around the world, accompanied by serious comorbidities and significant psychosocial limitations among those affected. There is still an insufficient number of treatments

and prevention programs [1]. Amongst 6- to 14-year-olds in Austria, one fifth of boys and more than one sixth of girls are overweight or obese [2].

For many years the focus of research has been on the risk factors which contribute to the development of obesity. A combination of genetic determination, social factors and lifestyle factors are presumed to be responsible [3]. The role sleep duration plays in this context is one of the factors that has been investigated. Observations have shown that as the prevalence of obesity increases, the sleeping period decreases [4–6]. Numerous cross-sectional studies related to sleep duration and body mass index (BMI) in adults, as

## Objectives

The research question is: Is there an association between sleep duration and BMI in 10- to 14-year-old children in Austria?

The study also investigated whether there were gender-specific differences and whether socio-demographic factors (birth country, school type) had an influence. Additionally, the influence of sleep characteristics (sleep disturbances, activity before going to sleep) on the BMI was recorded. The result should ideally be able to provide recommendations on sleep hygiene for children and young people, which could represent a cost-effective and easy-to-implement measure as part of the obesity prevention framework.

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## Methods

These results are based on a bachelor thesis which was drawn up in 2012 as part of a course on dietetics at the Fachhochschule St. Pölten.

In a quantitative, non-invasive cross-sectional study (n = 301), anthropometric and socio-demographic data and sleeping habits were recorded by means of a standardized questionnaire (15 items). The questionnaire was carried out anonymously. All data was based on self-evaluation.

The tested persons were recruited from grade 5 to 8 at various Austrian schools, (Allgemeinbildende höhere Schulen [general high schools], Hauptschulen [secondary schools], Kooperative Mittelschulen [cooperative middle schools] and Neue Mittelschulen [new middle schools]). Students aged under 10 or aged 15 and over were excluded. Overall, 366 questionnaires were distributed. The response rate was 90.2 % (330 questionnaires); after the adjustment of the study population for item non-responsive failures (missing information on key parameters such as body size, body weight, gender, age), there was a net study population of 301. The study population for sleep duration was smaller (n = 266), as information on this was missing from several participants. According to the BMI threshold values for overweight and obesity devised by KROMEYER-HAUSCHILD et al. [9], the participants were defined as overweight when their BMI calculated from information provided on size and weight was over the 90<sup>th</sup> percentile, and as obese when their BMI was over the 97<sup>th</sup> percentile.

### Determination of sleep habits

For the determination of sleep habits, the questions focused on the school day and the nights before school days, in order to obtain a comparable regular sleeping pattern. In addition to sleep duration, other sleep behavior was recorded, such as waking up at

night, naps in the afternoon and activity before going to sleep. Questions were asked about the time of going to sleep (responses given in half-hourly categories) and the wake-up-time (open response).

Sleep duration was calculated from both these responses and used in the evaluation. Participants were also questioned directly about sleep duration (how many hours do you sleep when you're going to school on the following day?). The direct question about sleep duration served as a control question. The participants who had entered "after 11 p.m." as the time of going to sleep could not be taken into account in the calculation of sleep duration as it was not possible to calculate sleep duration with this information (period of time, not point in time).

There are no specific recommendations for sleep duration for children and young people, as individual sleeping needs greatly differ. Therefore a threshold value was defined in advance for the evaluation of results. Based on recommendations by the Centers for Disease Control and Prevention (CDC) [10] and by STORES [11], a nightly sleep duration of less than 8.5 hours was determined as *too short* for the target group. Sleep duration of at least 8.5 hours was *sufficient*. (For comparison: IGLOWSTEIN et al. meas-

ured an average nightly sleep duration of 8.6 to 9.9 hours for 10- to 14-year-old children [12].) Due to the low number of participants, a dichotomization was practical.

### Data evaluation

Overall, 301 participants were included in the analysis (57.8 % female, 42.4 % male). The mean age was 12.7 ( $\pm 1.0$ ) years. Due to missing data, information about sleep duration was only available for 266 participants. Odds ratios and their corresponding 95 % confidence intervals were obtained by using logistic regression procedures. Relations between interval-scales variables were calculated by means of Spearman's rank correlation coefficient.

A two-sided p-value < 0.05 was considered statistically significant. All statistical analyses were performed using SPSS Statistics 19.0 (2010).

## Results

◆ Figure 1 shows the distribution of overweight/obesity, normal weight and underweight according to sleep duration.

When we analyzed the association of sleep duration and weight, the risk for overweight or obesity was higher for those with too short sleep duration

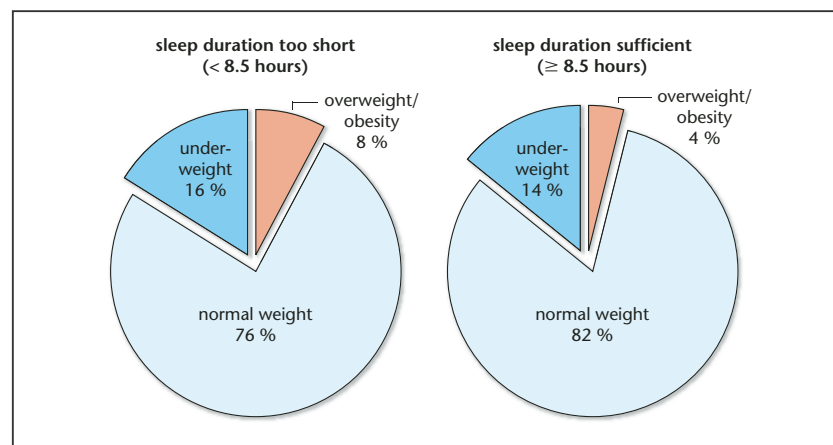


Fig. 1: Distribution of overweight/obesity, normal weight and underweight according to sleep duration (n = 266)

compared to those with sufficient sleep duration. However, this result was not significant ( $n = 266$ ; OR 2.0;  $p = 0.211$ ; ♦ Table 1). There was a significant, but small correlation between BMI and sleep duration: the shorter the night's sleep, the higher the BMI ( $n = 266$ ,  $r = -0.186$ ,  $p = 0.002$ ; data not shown). Interestingly, we found a gender-specific difference (♦ Table 2): 10- to 14-year-old boys who slept too little ( $< 8.5$  hours) had a significantly increased risk of overweight/obesity than those with sufficient sleep duration ( $n = 109$ ; OR 6.1;  $p = 0.033$ ). Even after adjusting for confounding variables (birth country, school type) this result remained statistically significant ( $n = 108$ ; OR 6.2;  $p = 0.032$ ).

In the girls group, this finding could not be confirmed ( $n = 157$ ; OR 0.4;  $p = 0.404$ ), even after adjustment for birth country and school type. Associations between BMI and other sleep characteristics (time of going to sleep, afternoon nap) were only moderate (data not shown).

Direct results regarding sleep duration (based on the question: "how many hours do you sleep when you're going to school on the following day?") differed slightly from the calculated sleep duration (based on the bedtime and the wake-up time), as they were a little lower (♦ Table 3).

### Discussion and limitations

In this study we found a significant association between sleep duration and overweight/obesity in 10- to 14-year-old boys. For girls of the same age group, no significant association could be shown.

### Limitations

This study was subject to various limitations. A correlation arose from the cross-sectional study, yet no causal conclusions could be drawn as to *why* (too short) sleep duration was linked to greater weight among boys. The study population was also not representative (e. g. the group of 13-year-olds was over-represented).

Furthermore, the questionnaire could not be implemented in a fully standardized manner (as it could have been filled in at school or at home, potential assistance given by adults). Information on body weight, body size and sleep duration could only be requested, not measured. It must be assumed that some participants simply estimated these values. The proportion of overweight/obese children is remarkably low. An Austrian study on the prevalence of overweight among 6- to 14-year-old children showed that 20.2 % of boys and 17.7 % of girls were overweight or obese [2]; in this study only 8.7 % of boys and 5.2 % of girls were overweight or obese (♦ Table 4).

The sleep duration figure used in the evaluation was the one calculated as the period of time between the bedtime and the wake-up-time. It frequently differed, even if only slightly, from information provided by the participants in response to the direct question about their sleep duration.

	n (%)	Risk of overweight/obesity		Risk of underweight	
		OR (95 %-CI)	p-value	OR (95 %-CI)	p-value
<b>Sleep duration</b> (n = 266)					
too short	93 (35.0)	2.0 (0.68–5.92)	0.211	1.3 (0.62–2.53)	0.535
sufficient	173 (65.0)	ref.		ref.	
<b>Age</b> (n = 301)					
10–11 years*	65 (21.6)	0.6 (0.10–4.0)	0.617	0.7 (0.22–2.48)	0.634
12 years	88 (29.2)	0.9 (0.16–4.91)	0.891	1.5 (0.50–4.43)	0.473
13 years	119 (39.5)	1.1 (0.22–5.32)	0.916	0.3 (0.10–1.17)	0.087
14 years	29 (9.6)	ref.		ref.	
<b>Birth country</b> (n = 300)					
Austria	239 (79.7)	0.9 (0.30–2.47)	0.779	3.7 (1.11–12.53)	0.034
other	61 (20.3)	ref.		ref.	
<b>Gender</b> (n = 301)					
female	174 (57.8)	0.6 (0.2–1.48)	0.264	1.2 (0.63–2.39)	0.556
male	127 (42.2)	ref.		ref.	
<b>School type</b> (n = 301)					
HS/NMS/KMS	114 (37.9)	2.3 (0.91–5.73)	0.079	1.6 (0.84–3.13)	0.147
AHS	187 (62.1)	ref.		ref.	

Tab. 1: Risk of overweight/obesity and underweight in 10-to 14-year-old children (n = 301)  
 95 % CI = 95 % confidence interval, AHS = Allgemeinbildende höhere Schule [general secondary school];  
 HS = Hauptschule [secondary school], KMS = Kooperative Mittelschule [cooperative middle school],  
 NMS = Neue Mittelschule [new middle school], OR = odds ratio, ref. = reference category  
 Due to partially missing information, the individual variables did not always amount to n = 301.  
 \*Due to the low number of participants, 10- and 11-year-old children were put into one category.

	n (%)	Risk of overweight/obesity	
		OR (95 %-CI)	p-value
<b>Girls and boys overall* (n = 266)</b>			
too short sleep duration	93 (35.0)	2.0 (0.68–5.92)	0.211
sufficient sleep duration	173 (65.0)	ref.	
<b>Girls overall, without adjustment for confounding variables (n = 157)</b>			
too short sleep duration	54 (34.4)	0.4 (0.05–3.49)	0.404
sufficient sleep duration	103 (65.6)	ref.	
<b>Boys overall, without adjustment for confounding variables (n = 109)</b>			
too short sleep duration	39 (35.8)	<b>6.1 (1.16–32.22)</b>	<b>0.033</b>
sufficient sleep duration	70 (64.2)	ref.	
<b>Boys overall, adjusted for birth country** (n = 108)</b>			
too short sleep duration	38 (35.2)	<b>6.2 (1.17–32.46)</b>	<b>0.032</b>
sufficient sleep duration	70 (64.8)	ref.	
<b>Boys overall, adjusted for birth country and school type** (n = 108)**</b>			
too short sleep duration	38 (35.2)	<b>6.2 (1.17–33.27)</b>	<b>0.032</b>
sufficient sleep duration	70 (64.8)	ref.	

Tab. 2: Risk of overweight/obesity in the event of too short sleep duration (10- to 14-year-old children), gender-specific differences (n = 266)  
95 % CI = confidence interval, OR = odds ratio, ref. = reference category  
Values in bold = significant results, see p-value  
\*All participants (n = 301) could not be considered due to partially missing information.  
\*\*One participant could not be considered due to missing information on birth country (n = 108).

### Sleep duration or sleep problems: questionable causality

The fact that overweight people sleep worse than those of normal weight should be taken into account for all studies on the association between overweight and lack of sleep [13]. Therefore, the problem is the questionable causality: Is overweight (partially) caused by lack of sleep or do sleep problems occur because the person is overweight [14]?

In larger studies on the issue of sleep duration and body weight, participants were usually only asked about sleep duration [5]. The results of this study largely coincide with related international literature [5, 7, 15, 16]. In their meta-analysis of seven studies, CAPPUCIO et al. [16] found an odds ratio [OR] of 1.89 in children with short sleep duration. The meta-analysis by CHEN et al. [15] concluded that the risk of overweight or obesity was increased (OR 1.58) for children with shorter sleep duration.

Those who slept for the shortest time were particularly at risk (OR 1.92).

A similar OR was generated in this study for the overall study population. However, the correlation was not significant when not divided by gender.

SHI et al. [7] studied children of comparable age groups (5 to 15 years) and reported on the tendency that boys had a higher risk of obesity

with lack of sleep than girls; the gender-specific difference, however, was not significant. In the meta-analyses by CHEN et al. [15] and PATEL and HU [5] there were also indications of a gender-specific difference: boys seem to react more sensitively than girls to shortened sleep duration in the development of body weight. The results of this evaluation also agree. Further studies could focus on this gender-specific difference, the causes of which are still unclear.

Recent research shows that sleep duration also influences body composition: too short sleep duration in early childhood is associated with higher body fat mass [8]. VON KRIES et al. [17] found that there was an increased risk of obesity and an increased body fat mass among 5- to 6-year-old children in Germany with shorter sleep duration, irrespective of numerous other risk factors for obesity. The effect of sleep duration on body composition and especially on body fat percentage was not recorded as part of this study.

The studies cited were only able to determine a correlation between (shorter) sleep duration and overweight; intervention studies would however be necessary to provide evidence of the causes. Studies with a sufficiently large study population and a study design that allowed causal conclusions could help to obtain meaningful results in this area.

variable*	overall	girls	boys
<b>calculated sleep duration** in hours</b>	<b>n = 266</b>	<b>n = 157</b>	<b>n = 109</b>
mean (± SD)	8.7 (± 0.8)	8.7 (± 0.8)	8.7 (± 0.9)
median (IQR)	8.7 (8.0–9.3)	8.7 (8.0–9.3)	8.8 (8.0–9.3)
<b>given sleep duration in hours</b>	<b>n = 288</b>	<b>n = 167</b>	<b>n = 121</b>
mean (± SD)	8.4 (± 1.2)	8.4 (± 1.1)	8.3 (± 1.3)
median (IQR)	8.5 (8.0–9.0)	8.5 (8.0–9.0)	8.5 (7.9–9.0)

Tab. 3: Calculated and given sleep duration (n = 266 and 288)  
IQR = interquartile range, SD = standard deviation  
\*Due to partially missing information, the total individual variables do not result in n = 301.  
\*\*No evaluation possible in the event of missing information and time of going to sleep marked as "after 11 p.m."

### Conclusion

(Too) short sleep duration is one of many risk factors for overweight and obesity. With regard to activities relating to nutritional medicine and public health, it can be said that healthy sleep hygiene should be taken into account in obesity prevention programs. Even though the recommendation of a sufficient night's sleep is not a therapeutic approach to obesity, it is a possible cost-effective measure in prevention – notwithstanding the fact that the corresponding sleep duration could positively affect the BMI, it would at least benefit well-being and cognitive performance [18].

Further studies on the subject are required to investigate the association between sleep duration and body weight more thoroughly, particularly whether lack of sleep can be accepted as a possible cause of overweight. If a similar gender-specific difference was found in representative studies as in this study, it would be possible to focus on boys and male young people.

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#### Conflict of Interest

The authors declare no conflict of interest according to the guidelines of the International Committee of Medical Journal Editors.

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	Austria (6- to 14-year-old children) [2]		Net study population (10- to 14-year-old children) (own evaluation)	
	male	female	male	female
<b>Obesity/overweight</b>	20.2 %	17.7 %	8.7 %	5.2 %
<b>Normal weight</b>	75.1 %	76.5 %	78.7 %	79.3 %
<b>Underweight</b>	4.7 %	5.8 %	12.6 %	15.5 %

Tab. 4: Prevalence of overweight/obesity in 6- to 14-year-old children in Austria

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