



## Relations between sleep duration with overweight and academic stress—just a matter of the socioeconomic status?

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### ABSTRACT

**Objectives:** Shorter sleep duration in childhood has already been associated with health-related and psychological factors, such as overweight/obesity or stress. This study investigates associations of sleep duration with overweight/obesity and stress related to academic success in school (“academic stress”) in dependence on children’s socioeconomic status.

**Design:** Cross-sectional.

**Setting:** LIFE Child Study, a study investigating child development from pregnancy to adulthood.

**Participants:** A total of 1537 (2325 observations) 1- to 14-year-old children were considered. Analyses on academic stress were performed in a subgroup of 450 school-aged children (631 observations).

**Measurements:** Associations between sleep duration and overweight/obesity as well as academic stress were analyzed using linear mixed-effect regression models controlling for multiple visits. Importantly, all associations were checked for interactions with families’ socioeconomic status.

**Results:** The analyses revealed negative associations between sleep duration and overweight/obesity as well as academic stress, which, however, were only observable in children from families with a low socioeconomic status. The associations were consistent across all ages.

**Conclusions:** The findings suggest that children from families with a low socioeconomic status have a higher susceptibility for risk factors promoting sleep deficiency, overweight, or academic stress, for example, unhealthy food intake, high media consumption, or the loss of coping strategies for academic stress at school.

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### Introduction

Adequate sleep is a prerequisite for healthy child development and well-being.<sup>1</sup> Therefore, the gradual decline in children’s and adolescents’ sleep duration observed in the past decades due to changes in life-style behavior and extended use of technological devices is alarming.<sup>1</sup>

The first aim of this study was to investigate associations between shorter sleep duration and a selection of potentially influencing parameters, namely, overweight/obesity as an health-related factor on the one hand and stress related to academic success in school (in the following referred to as *academic stress*) as a psychological factor on the other hand. The central aim of this study, however, was to explore if these potential associations are mediated by children’s socioeconomic status (SES), as sleep duration, overweight, and stress

factors have already been observed to be dependent on socioeconomic variables.<sup>2–5</sup>

Overweight, including obesity, was chosen for this study, as this condition is still frequent in children and adolescents in Germany (prevalence of 18.9% of the children and adolescents aged between 11 and 17 years), although the prevalence has stabilized in the past years.<sup>6,7</sup> Combined with its associated comorbidities, overweight/obesity leads to enormous challenges for the health care system.<sup>8</sup>

So far, many studies revealed associations between increasing body mass index (BMI) and shorter sleep duration in children.<sup>9–11</sup> However, the direction of effects is still unclear. Sleep deficiency might cause weight gain, for example, by changes in hormone levels, such as diminished leptin and elevated ghrelin levels, resulting in an increased food intake.<sup>11</sup> Also, reduced physical activity and the proneness to sedentary activities due to daytime sleepiness are seen as contributors to overweight.<sup>12</sup> On the contrary, it is argued that overweight might lead to sleep problems. For example, massive fat storage in the upper

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airways, as it is observed in patients suffering from obstructive sleep apnea, results in a disturbed and shortened sleep.<sup>13</sup>

The impact of the SES on the association between overweight/obesity and sleep duration has already been investigated. Whereas, in some studies, the association remained stable even after adjusting for the SES,<sup>14,15</sup> other studies revealed a dependence of the SES.<sup>16,17</sup> Here, the association was shown to be stronger in low-SES families. The explanation provided by the authors was that children with a low SES might more frequently live in environments promoting obesity or sleep deficiency.<sup>17</sup>

The present study additionally assessed academic stress as a potential psychological factor associated with children's sleep duration. Academic stress was selected, as most of the waking time of school-aged children is spent at school, suggesting that concerns about academic success are important risk factors for health problems.<sup>18,19</sup> In contrast to poor academic achievement as an objective measure of success at school (eg, marks, test scores) that has been associated with sleep loss, academic stress reflects children's subjective perspectives on success and failure at school. To our knowledge, relations to sleep duration have not been investigated in early adolescence before. However, other stress factors at school like bullying or psychological distress have been shown to be linked to shorter sleep durations.<sup>20,21</sup> Moreover, perceived stress has been related to shorter sleep durations and sleep disturbances.<sup>22</sup> The corresponding increased levels of cortisol secretion might result in hyperarousal sleep and delayed sleep onset.<sup>23</sup> With respect to a possible influence of the SES, the relation between sleep efficiency and better cognitive performance has been shown to be particularly strong in low-income families.<sup>24</sup>

We expected to find significant relations of sleep duration (total sleep duration as well as problems related to sleep duration) with overweight/obesity and academic stress. As children from low-SES families are generally reported to be prone to unhealthy behaviors,<sup>25</sup> we, furthermore, hypothesized that these relations are stronger in these families compared to families with a middle to high SES. Moreover, it was explored whether these relations remain stable in a multiple analysis and differ across childhood, as a large sample covering the age period from 1 to 14 years (9 to 14 years in the case of academic stress) was studied.

## Methods

### Study design and setting

The present cross-sectional study project was realized by using data from the LIFE Child Study (Leipzig, Germany). This study is a German population-based cohort study combining a cross-sectional and a longitudinal design, which aims to describe a healthy child development and to detect protecting contributors or risk factors for lifestyle diseases. More than 4000 participants have been recruited since study initiation in 2011 via advertisement at different institutions, for example, hospitals or clinics, but also in schools or via word of mouth. All participants are invited to attend follow-up visits once a year.<sup>26</sup> The LIFE Child Study was approved by the Ethical Committee of the Medical Faculty of the University of Leipzig (reg. no. 264-10-19042010) and registered with the clinical trial number NCT02550236. All parents as well as children older than 12 years provided written consent prior to participation.

### Participants

The main criterion for inclusion in the present study was the availability of complete information on sleep duration, SES, and BMI and was met by 1558 children aged between 1 and 14 years. Some children had participated at more than 1 study visit, leading to a total of 2356 observations. All observations were included to increase the validity of the results. As shown in Fig. 1, 21 children were excluded because of the intake of any medication interacting with sleep (eg, levetiracetam,

oxacarbazepine, valproate, risperidone, midazolam, lisdexamfetamine, methylphenidate, atomoxetine). The final study sample consisted of 2325 observations from 1537 children and adolescents aged between 1 and 14 years (mean [ $M$ ] = 7.23 years, SD = 3.72 years, Table 1). A total of 47.3% were female and 52.7% were male. Information on academic stress was available in a subgroup of children older than 9 years only. Therefore, the analyses including this information were performed in a subsample comprising 631 observations from 450 participants ( $M$  = 11.91 years, SD = 1.19 years, 49.3% female, 50.7% male, Table 1). Due to item-specific missings in a subscale measuring problems related to sleep duration, analyses including this subscale were performed in 1317 children of the study sample and 382 children of the subgroup.

### Data sources/measurement

Sleep duration was assessed by the Children's Sleep Habits Questionnaire (CSHQ).<sup>27</sup> Parents reported their children's "usual amount of sleep each day (combining night time sleep and naps)" in full hours and minutes. To avoid biases due to age- and sex-dependent physiological changes in sleep behavior,<sup>28</sup> sleep duration was standardized for age and sex using the LMS method,<sup>29</sup> resulting in respective standard deviation scores (SDS). In addition, the CSHQ subscale "sleep duration," measuring problems related to sleep duration, was analyzed. It contains 3 items ("child sleeps too little," "child sleeps the same amount each day," "child sleeps too much"). Each question can be answered by either "rarely (0–1 time/wk)," "sometimes (2–4 times/wk)," or "usually (5–7 times/wk)." The final score may range between 3 and 9, with higher scores indicating more problems.<sup>27</sup>

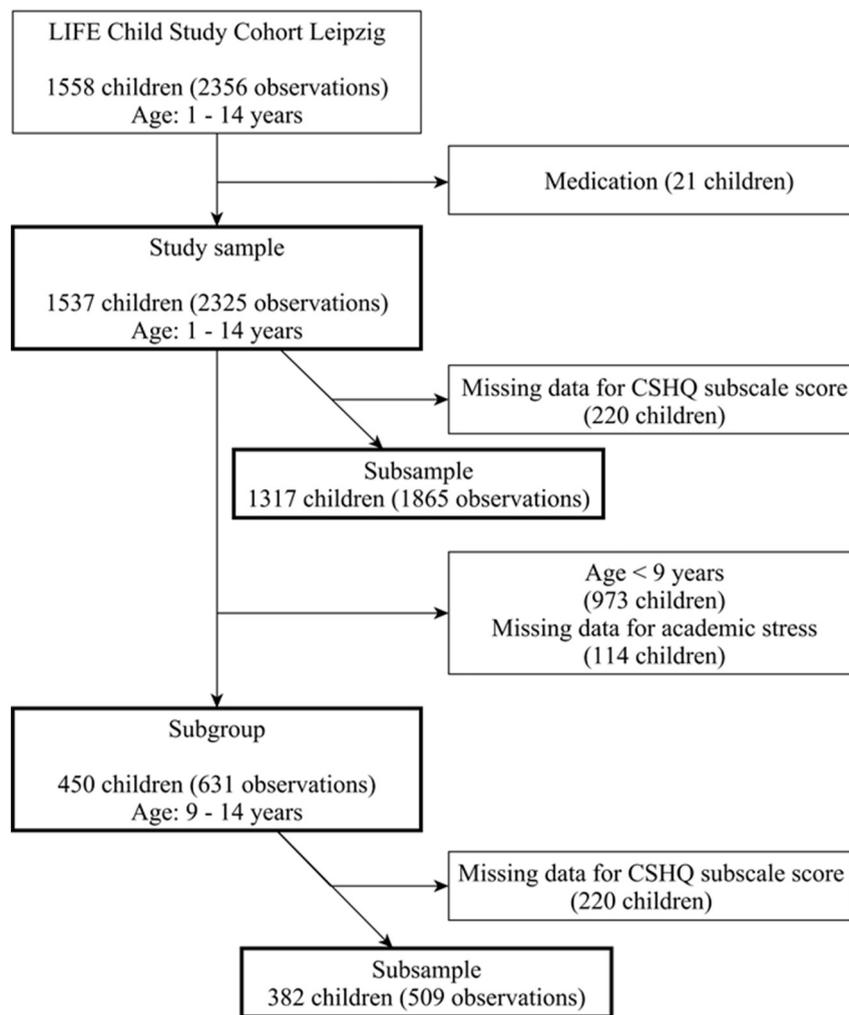
Weight and height were measured in a standardized procedure by trained study assistants. Based on German reference values,<sup>30</sup> the BMI was adjusted for age and sex, resulting in standard deviation scores (SDS). Participants were categorized as overweight/obese for a BMI SDS higher than 1.28.<sup>30</sup>

The SES was assessed by measuring parents' monthly net income, their graduation (highest school degree and highest profession), as well as their occupational status (professional position).<sup>31</sup> The family's net income was transformed to the equivalent household income by accounting for the number of family members living in the same household. For each of the 3 components, a score between 1 and 7 was assigned, with higher scores representing higher income, graduation, or occupational status. The sum of these components corresponded to the SES composite score ranging from 3 to 21, with higher scores indicating higher SES. Only the highest education and the highest occupational status of both parents were considered to calculate the SES score of the family.<sup>31</sup> For further analysis, the SES was dichotomized with a cutoff at an SES score of 7. According to Lampert et al,<sup>31</sup> scores between 3.0 and 8.4 indicate a low SES (middle SES: between 8.5 and 15.4, high SES: between 15.5 and 21.0). However, the score of 7 was chosen as cutoff, as the highest discriminating effects were observed at this point. In the following, scores up to 7 were referred to as "low SES" and scores above as "middle to high SES".

Academic stress was assessed in a life events questionnaire by the question "Have you ever experienced academic stress referring to your academic achievement in school during the past six months?" and could be answered by either "yes" or "no." The questionnaire was assessed for participants older than 9 years, as answers from younger participants were not considered to be valid because of their reading and writing literacy.

### Statistical methods

All data were analyzed and visualized using R. For descriptive purposes, the amounts of overweight/obesity, academic stress, and low SES were reported for the first visit of each participant.



**Fig. 1.** Composition of the study sample and its subgroup from the LIFE Child Study cohort of Leipzig. The flowchart diagram demonstrates the study sample, which includes 1537 participants aged between 1 and 14 years and for whom complete information about sleep duration, weight, height, SES, age, and sex was available. Twenty-one children were excluded because of the intake of medication interfering with sleep. The subgroup consists of 450 children aged 9 to 14 years, in which information about academic stress was obtained. Subsamples of the study sample and the subgroup were created to analyze the CSHQ subscale “sleep duration.”

The investigation of associations of overweight/obesity or academic stress with sleep duration was performed by mixed-effect multiple linear regression analyses, as implemented in the R package *lme4*.<sup>32</sup> The significance level  $\alpha$  was set to .05 for all regression models. To account for multiple measures per participant (multiple study visits) and multiple participants per family (family membership), the participant nested within the family was included as random effect.

First, overweight/obesity or academic stress and the control variables age and sex were included as independent variables, and sleep duration SDS or the CSHQ score “sleep duration” were included as outcome variable. To explore if possible associations of overweight/obesity or academic stress with sleep duration differ depending on SES, the interactions between SES and overweight/obesity or academic stress were simultaneously included as independent variables in the multiple regressions described above. Finally, it was investigated whether possible associations remain significant in a multiple analysis in the subgroup. In this model, overweight/obesity, academic stress, as well as the interactions between weight group and SES, between weight group and academic stress, and between academic stress and SES were included as independent variables.

Furthermore, all statistical models were checked for interactions between the independent variables and age (including the 3-way

interactions between weight group or academic stress, SES, and age). An interaction with age was only included in the final model if both of the following 2 preconditions were met. First, the interaction had to be significant ( $P < .05$ ). Second, the model quality had to be preserved, that is, the interaction term did not cause a severe inflation of variance (variance inflation factor  $< 5$ ).

It is important to note that the analyses may include several observations of the same child. However, all analyses are cross-sectional, as the relations were always investigated at the same time point.

## Results

### Descriptive statistic

As expected, sleep duration declined with growing age ( $b = -0.29, P < .001$ ). Whereas 1- to 2-year-old toddlers slept between 8 and 16 hours per day ( $M = 12.26, SD = 1.43$ ), adolescents aged 13 or 14 slept between 6.5 and 10.0 hours ( $M = 8.61, SD = 0.72, Fig. 2$ ). Sex differences in sleep durations were not observed ( $b = 0.08, P = .243, Fig. 2$ ). Characteristics of the study sample and its subgroup are presented in Table 1. Overweight/obesity was observed in 14.8% of the study participants and in 21.3% of the subgroup. A total of 20.5% of the study sample and 18.9% in the subgroup belonged to

**Table 1**  
 Characteristics of the study sample (age 1 to 14 years) and the subgroup (age 9 to 14 years)

	Study sample (n = 1537)			Subgroup (n = 450)		
	M (SD)	Mdn	n (%)	M (SD)	Mdn	n (%)
Age (y)	7.23 (3.72)	7.26		11.91 (1.19)	11.81	
1-2			279 (18.2%)			0 (0.0%)
3-4			203 (13.2%)			0 (0.0%)
5-6			266 (17.3%)			0 (0.0%)
7-8			257 (16.7%)			0 (0.0%)
9-10			238 (15.5%)			120 (26.7%)
11-12			198 (12.9%)			234 (52.0%)
13-14			96 (6.2%)			96 (21.3%)
Sleep duration SDS	0.02 (0.97)	0.08		0.02 (0.98)	0.05	
Sleep duration (subscale CSHQ)	3.85 <sup>a</sup>	3.00 <sup>a</sup>		4.09 <sup>b</sup>	3.00 <sup>b</sup>	
Sex						
Female			727 (47.3%)			222 (49.3%)
Male			810 (52.7%)			228 (50.7%)
Weight group						
Overweight/obesity			227 (14.8%)			96 (21.3%)
No overweight/obesity			1310 (85.2%)			354 (78.7%)
SES						
Lower SES			315 (20.5%)			85 (18.9%)
Higher SES			1222 (79.5%)			365 (81.1%)
Academic stress						
Yes						121 (26.9%)
No						329 (73.1%)

SDS: adjusted for age and sex.  
 Overweight/obesity: BMI SDS > 1.28; no overweight/ obesity: BMI SDS ≤ 1.28.  
 Lower SES: SES score ≤ 7; higher SES: SES score > 7.  
<sup>a</sup> n = 1317  
<sup>b</sup> n = 382

families with a “low SES,” whereas 79.5% came from families with a “middle to high SES” (81.1% in the subgroup). Academic stress was reported by 26.9% of the participants in the subgroup.

*Associations of sleep duration with overweight/obesity depending on SES*

In the study sample, overweight/obesity was significantly related to lower sleep duration SDS ( $b = -0.16, P = .012$ ). The association

between overweight/obesity and the CSHQ subscale “sleep duration,” however, was not significant ( $b = -0.01, P = .886$ ). Table 2 summarizes the regression analyses including the interaction between weight group and SES group as predictor. Interestingly, these analyses showed significant interactions between weight group and SES ( $b = -0.28, P = .029$  for sleep duration SDS as outcome,  $b = 0.42, P = .036$  for CSHQ subscale “sleep duration” as outcome). These interactions indicate that overweight/obesity was associated with

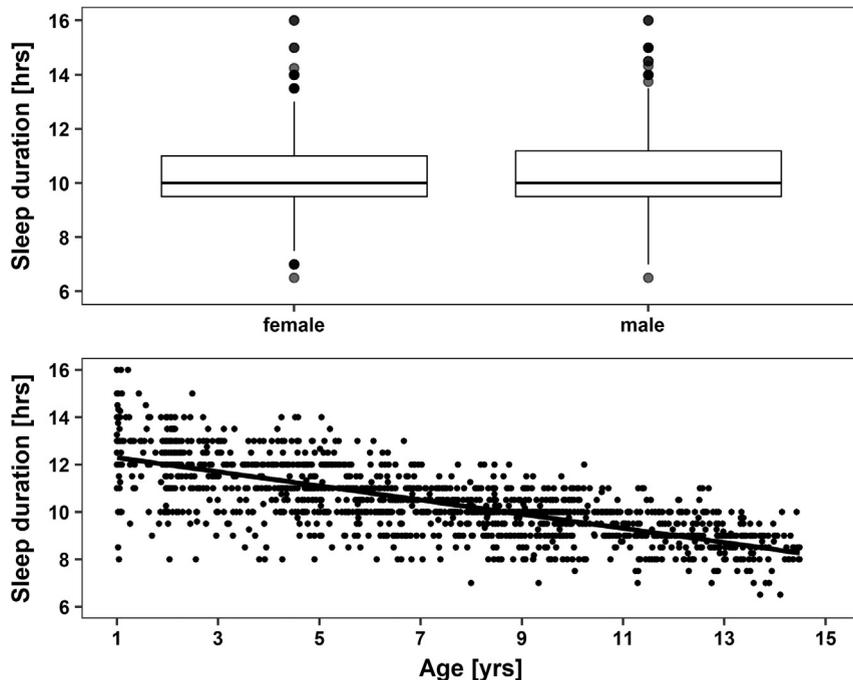


Fig. 2. Sleep duration is declining with increased age. No sex differences were observed (age 1–14 years, 2325 observations of 1537 children).

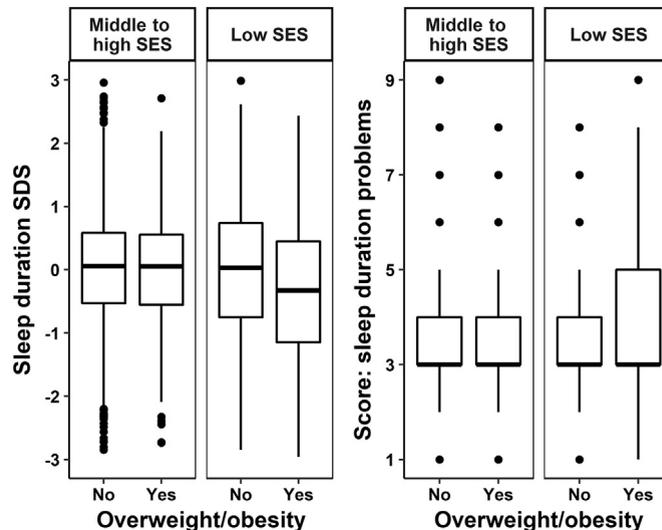
**Table 2**  
Overweight/obese participants with a low SES have significantly shorter sleep durations and more problems related to sleep duration

Predictor	Outcome					
	Sleep duration SDS n = 2235 (1537 children)			Sleep duration (CSHQ subscale) n = 1865 (1317 children)		
	<i>b</i>	SE	<i>P</i>	<i>b</i>	SE	<i>P</i>
Overweight/obesity <sup>a</sup>	−0.06	0.07	.398	−0.15	0.11	.175
Low SES <sup>b</sup>	0.04	0.06	.558	−0.03	0.10	.763
Interaction: weight group and SES	−0.28	0.13	.029	0.42	0.20	.036

Results from children aged between 1 and 14 years. All associations were adjusted for age and sex (linear mixed-effect regression model).

<sup>a</sup> Reference level: no overweight/obesity (BMI SDS ≤ 1.28).

<sup>b</sup> Reference level: middle to high SES (SES score > 7).



**Fig. 3.** Only in low-SES families is overweight/obesity associated with shorter sleep duration SDS (1537 children, 2325 observations) and problems with sleep duration (1317 children, 1865 observations). Age: 1–14 years. SDS: adjusted for age and sex. Middle to high SES: SES score > 7; low SES: SES score ≤ 7. Overweight/obesity: BMI SDS > 1.28; no overweight/obesity: BMI SDS ≤ 1.28.

shorter sleep duration SDS and higher scores in the CSHQ subscale “sleep duration” only if participants grew up in low-SES families (Fig. 3).

#### Associations of sleep duration with academic stress depending on SES

Associations between academic stress and sleep duration were assessed in the subgroup of older children. Without considering possible interactions with SES, academic stress was not related to sleep duration SDS ( $b = -0.12$ ,  $P = .141$ ) but to higher scores in the CSHQ subscale “sleep duration” ( $b = 0.32$ ,  $P = .016$ ). After including

the interaction in the model (Table 3), the analysis revealed a significant interaction between academic stress and SES for sleep duration SDS as outcome ( $b = -0.61$ ,  $P = .004$ ). This finding indicates that academic stress was negatively associated with sleep duration SDS in low-SES families but not in middle- to high-SES families (Fig. 4).

#### Multiple analyses on associations of sleep duration with overweight/obesity and academic stress depending on SES

To show if the interactions displayed in Tables 2 and 3 remain significant if overweight/obesity and academic stress were simultaneously

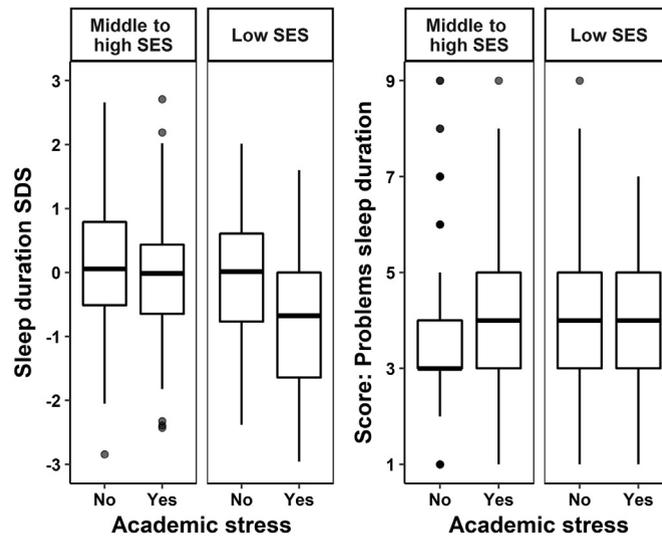
**Table 3**  
Participants experiencing academic stress with a low SES have significantly shorter sleep durations

Predictor	Outcome					
	Sleep duration SDS n = 631 (450 children)			Sleep duration (CSHQ subscale) n = 509 (382 children)		
	<i>b</i>	SE	<i>P</i>	<i>b</i>	SE	<i>P</i>
Low SES <sup>a</sup>	−0.04	0.12	.708	0.42	0.21	.041
Academic stress <sup>b</sup>	−0.02	0.09	.837	0.39	0.14	.007
Interaction: SES and academic stress	−0.61	0.21	.004	−0.38	0.39	.330

Results from children aged between 9 and 14 years. All associations were adjusted for age and sex (linear mixed-effect regression model).

<sup>a</sup> Reference level: middle to high SES (SES score > 7).

<sup>b</sup> Reference level: no academic stress.



**Fig. 4.** Only in low-SES families is academic stress associated with shorter sleep duration SDS (450 children, 631 observations). No associations are observed for problems related to sleep duration (382 children, 509 observations). Age: 9–14 years.

included as independent variables, a multiple regression analysis was performed (in the subgroup). For sleep duration SDS, the strength of the interaction between weight group and SES group was comparable to the one observed in the study sample ( $b = -0.36$ ). However, this interaction did not reach significance ( $P = .135$ ). For the subscale of the CSHQ, the interaction between weight group and SES was weaker than in the study population and also not significant ( $b = 0.13$ ,  $P = .763$ ). The interaction between SES and academic stress in relation to sleep duration SDS, however, remained significant ( $b = -0.57$ ,  $P = .007$ ).

#### Differences depending on child's age

The statistical models presented in Tables 2 and 3 were checked for interactions between each independent variable and child's age. However, interactions either did not reach significance or limited the quality of the model by causing a severe inflation of variance. Therefore, the observed associations reported in Tables 2 and 3, including the significant interactions between SES and overweight/obesity or academic stress, can be assumed to not differ depending on child's age.

#### Discussion

This project examined the association between sleep duration, overweight/obesity, and academic stress—under consideration of the SES—in healthy children and adolescents.

#### Sleep duration and overweight/obesity in dependency on the SES

In accordance with previous studies,<sup>9,20</sup> a negative association between sleep duration and overweight/obesity could be replicated in this study. Causes for this relationship might be an increased food intake after curtailed sleep duration due to hormonal changes but also diminished physical activity due to daytime sleepiness.<sup>11</sup>

Remarkably, this study revealed that the SES interfered with this relation: The association was only found in families showing a low SES but not in families with a middle to high SES. This finding was interestingly consistent across all ages. In the subgroup of older (9- to 14-year-old) children, the interaction between SES and weight group was as strong as in the whole study sample (although not significant) independently of the academic stress reported by the participants. Similarly to sleep duration, associations between problems

related to sleep duration and overweight/obesity were only observable in low-SES families. In the subgroup of older children, however, this interaction was not observable.

Prior published studies also investigated a link between sleep and obesity as a function of the SES.<sup>16,17</sup> Bagley and El-Sheikh<sup>17</sup> analyzed 228 9- to 12-year-old children and found an association between actigraphy-measured sleep duration and BMI only in families with higher family risk factors (including low maternal education and family poverty). Likewise, in a study including 81390 school-aged children, Hassan et al<sup>16</sup> observed an association between parent-reported insufficient sleep and obesity only in low-SES families.

Possible reasons for these interactions are that the awareness of health risks or the opportunities to show children a healthy behavior might differ depending on the family's SES. An imbalanced diet might be more common in low-SES families due to a limited awareness of the importance of a healthy diet or a limited ability to control children's food intake.<sup>33</sup> Also, physical activity might be less encouraged.<sup>34</sup> Therefore, an increased desire to consume energy foods as well as physical inactivity—caused by limited sleep and high daytime sleepiness<sup>12</sup>—might be less controlled in children from low social backgrounds. This might, in turn, lead to weight gain. But also, bedtimes and behavior at bedtime (eg, media use) might differ. In low-SES families, bedtimes might be less controlled, and media use at bedtime might be less inhibited.<sup>5</sup> There might, therefore, be a stronger risk for overweight/obese children to fall asleep late. It is important to note that the lack of physical activity or healthy diet might partly be explained by the higher financial burden in low-SES families. They might choose high-energy food because they could not afford healthy groceries.<sup>35</sup> Similarly, children might be less active in sport clubs because participation has to be paid.<sup>36</sup> Moreover, children might share their bedrooms with siblings, as these families live in smaller flats or the housing may be located in noisy environments. Both factors might impair children's sleep duration.<sup>3</sup>

Summarizing, in families with a low SES, there might exist more promoting factors for the simultaneous occurrence of overweight and curtailed sleep duration. The lack of age effects suggests that this moderating effect of the SES holds across ages.

#### Sleep duration and academic stress in dependency on the SES

Similar to what was observed for overweight/obesity, associations between academic stress and sleep duration were only observable in

children from families with a low SES. Again, this moderating effect of the SES was consistent across age and observable independently of children's weight group. Academic stress might cause problems falling asleep and thus curtail children's sleep durations due to concerns about school at bedtime.<sup>3</sup> In middle- to high-SES families, however, parents might speak more likely about school problems and help their children cope with their worries.<sup>37</sup> Accordingly, resilience strategies for academic stress might be better developed in children with a middle to high SES.<sup>38</sup> On the other hand, shortened sleep duration might lead to concentration problems at school and, consequently, to poorer academic achievement.<sup>20</sup> In families with a middle to high SES, poorer academic achievement due to sleep deficiency might be less pronounced because of parents' school-related engagement (eg, helping doing homework) or coping strategies of children.<sup>38</sup> Additionally, private tutoring for children to reduce academic stress might be less common in low-SES families because of high expenditures. Furthermore, environmental factors such as school environment might play a role. In schools situated in a high-SES area, even low-SES students have been reported to show a better academic achievement,<sup>39</sup> suggesting that academic stress might be also reduced in these school environments.

### Limitations and future research

Our study focused on children's sleep duration. However, further dimensions of sleep like snoring, daytime sleepiness, or sleep-onset latency were not studied. Furthermore, sleep duration was reported by the parents. It might be difficult for parents to estimate their children's sleep duration adequately,<sup>40</sup> especially in older children. Future studies might apply objective measures of sleep (eg, polysomnography or accelerometers) and distinguish between nighttime sleep and naps and between sleep at school days and during weekend or holidays. Finally, academic stress was assessed by 1 question only. More detailed assessments (eg, information about the impact of examination periods or differences between schools) might reveal further interesting findings.

### Conclusion

Irrespective of the child's age, relations of shorter sleep durations with overweight/obesity and academic stress are observable in low-SES families but not in middle- to high-SES families. These findings suggest the existence of risk factors in low-SES families which promote a negative interplay between sleep duration and health-related as well as psychological factors.

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### Disclosure

All authors confirm that there is no conflict of interest.

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