MIND, BRAIN, AND EDUCATION

The Relation Between Breakfast Skipping and School Performance in Adolescents

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ABSTRACT—Breakfast skipping is common in adolescents, but research on the effects of breakfast skipping on school performance is scarce. This current cross-sectional survey study of 605 adolescents aged 11–18 years investigated whether adolescents who habitually skip breakfast have lower end-of-term grades than adolescents who eat breakfast daily. Additionally, the roles of sleep behavior, namely chronotype, and attention were explored. Results showed that breakfast skippers performed lower at school than breakfast eaters. The findings were similar for younger and older adolescents and for boys and girls. Adolescents with an evening chronotype were more likely to skip breakfast, but chronotype was unrelated to school performance. Furthermore, attention problems partially mediated the relation between breakfast skipping and school performance. This large-scale study emphasizes the importance of breakfast as a determinant for school performance. The results give reason to investigate the mechanisms underlying the relation between skipping breakfast, attention, and school performance in more detail.

Proper nutrition is commonly believed to be important for school performance; it is considered to be an essential prerequisite for the potential to learn in children (Taras, 2005). In the Western world, where most school-aged children are well nourished, emphasis is placed on eating breakfast for optimal school performance. Eating breakfast might be particularly important during adolescence. Adolescents have high nutritional needs, due to brain development processes and physical growth, while at the same time they have the highest rate of breakfast skipping among school-aged children (Hoyland, Dye, & Lawton, 2009; Rampersaud, 2009). However, not much is known about the effects of breakfast skipping on their school performance. Reviews indicate that only few studies have investigated the relationship between breakfast skipping and school performance in adolescents (Ells et al., 2008; Hoyland et al., 2009; Rampersaud, 2009; Taras, 2005). Therefore, the current study investigated the relation between habitual breakfast consumption and school performance in adolescents attending secondary school (age range 11–18 years). In addition, we explored two potentially important mechanisms underlying this relationship by investigating the roles of sleep behavior and attention.

Depending on the definition of breakfast skipping, 10–30% of the adolescents (age range 11–18 years) can be classified as breakfast skippers (Rampersaud, Pereira, Girard, Adams, & Metzl, 2005). Adolescent breakfast skippers are more often girls and more often have a lower level of education (Keski-Rahkonen, Kaprio, Rissanen, Virkkunen, & Rose, 2003; Rampersaud et al., 2005; Shaw, 1998). Adolescent breakfast skippers are characterized by an unhealthy lifestyle, with behaviors such as smoking, irregular exercise, and alcohol and drug use. They make more unhealthy food choices and have a higher body mass index than breakfast eaters. Furthermore, they show more disinhibited behavior (Keski-Rahkonen et al., 2003; Rampersaud et al., 2005). Reasons adolescents give for skipping breakfast are that they are not hungry or do not have enough time (Shaw, 1998), although dieting seems to play a role as well (Rampersaud et al., 2005; Shaw, 1998).

Experimental studies have investigated the relationship between breakfast skipping and cognitive functioning, which is assumed to underlie school performance. Breakfast skipping in children and adolescents appeared to affect memory and attention, especially toward the end of the morning (Ells et al., 2008; Hoyland et al., 2009; Rampersaud et al., 2005).

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For example, in an experimental study with a crossover design, boarding school students aged 13–20 were either given breakfast or not given breakfast. Skipping breakfast had an adverse effect on mood and short-term memory. In boys, it mostly affected visuospatial memory; in girls, verbal memory. All participants felt less alert after skipping breakfast; boys also had a less positive mood (Widenhorn-Müller, Hille, Klenk, & Weiland, 2008). Although these experimental studies point to negative consequences of breakfast skipping, they only investigated short-term effects and did not measure school performance directly (Taras, 2005). Moreover, they often did not control for habitual breakfast consumption, which may be an important confounder in studies where a standard breakfast condition is compared with a no-breakfast condition (Ells et al., 2008).

Survey studies can be used to investigate the long-term effects of habitual breakfast skipping on school performance. Edwards, Mauch, and Winkelman (2011) found that breakfast skipping was associated with lower math scores, but that it had no relationship with reading performance in 800 sixth-grade students. Hoyland et al. (2009) systematically reviewed survey studies on habitual breakfast skipping and school performance in well-nourished children and adolescents. They found only four studies focusing specifically on adolescent breakfast behavior (Fernández, Aguilar, Mateos, & Martínez, 2008; Herrero & Fillat, 2006; Lien, 2007; López-Sobaler, Ortega, Quintas, Navia, & Requejo, 2003). López-Sobaler et al. investigated a sample of 180 students aged 9–13 years, who recorded their eating habits for 1 week and took a scholastic aptitude test. Results showed that students who ate adequate breakfast scored better on reasoning. Herrero and Fillat investigated the relation between breakfast quality and average school grade in 140 students aged 12–13. Students indicated on a questionnaire what they had eaten for breakfast the day before. The study showed that poor breakfast quality was related to poor grades. Fernández et al. studied 467 adolescents between 12 and 17 years and related their 1-week eating habits to school grades. It appeared that mean school grade was related to breakfast consumption, although results varied for the different school subjects. Lien studied 7,343 adolescents aged 15–16 years, who answered a question on their habitual breakfast habits. Breakfast skipping appeared to be related to lower self-reported school grades. Thus, all these studies concluded that breakfast skipping was negatively related to school performance. This effect seemed to be even stronger in the case of boys than in the case of girls (Lien, 2007).

As Hoyland et al. (2009) already indicated, the four studies in their review were difficult to compare. All studies used different measures to investigate breakfast skipping and school performance; three of the studies were conducted in Spain; and one was sponsored by the food industry. Moreover, the main obstacle encountered was that not all studies took the same background variables into account (Hoyland et al., 2009). The results may be confounded by factors such as socioeconomic status, IQ, age, and nutritional status (Rampersaud, 2009).

Therefore, the first aim of the current cross-sectional survey study was to investigate the relationship between habitual breakfast skipping and educational outcomes in adolescents aged 11–18, while controlling for potential confounders, such as age, sex, educational track followed by the adolescent, level of parental education (LPE), and repeating or skipping a grade. The adolescents who participated were recruited from the two most advanced educational tracks in the Dutch education system. Approximately 40% of all students in Dutch secondary education study at these levels (Ministry of Education, Culture and Science, 2009). Breakfast skipping was defined as "not eating breakfast every school day." Educational outcomes were measured with end-of-term grades. It was hypothesized that adolescents who regularly skip breakfast perform lower at school.

We expected the relation between breakfast and performance to be different for younger and older adolescents. Our expectations are based on neuroanatomical studies, which have found that young, middle, and late adolescents differ in brain maturation (e.g., Giedd, 2008; Gogtay et al., 2004). In addition, the brains of younger and older adolescents vary in glucose metabolism (Chugani, 1998). Chugani showed that the brains of children and young adolescents need more glucose than the brains of 16–18 year olds. The brains of the latter group almost resemble adults' brains. Although this was not addressed directly in the current study, it has been suggested that blood glucose or its correlates are part of the biological mechanisms through which breakfast influences performance (Hoyland et al., 2009; Rampersaud, 2009). Besides a relation with age, we expected to identify sex differences, as previous studies have shown that effects of breakfast skipping on performance differ between boys and girls (Lien, 2007; Widenhorn-Müller et al., 2008). We also controlled for educational track followed by adolescents and LPE (Lien, 2007; Rampersaud, 2009). LPE can be seen as a proxy for the intellectual milieu in which the child grows up. LPE is often used as an estimator of socioeconomic status (e.g., Kalff et al., 2001), which is related to both breakfast behavior and school performance (Keski-Rahkonen et al., 2003; Rampersaud, 2009). Finally, students who repeated or skipped a grade were excluded from the analyses to control for their different educational careers.

The second aim of the current study was to investigate two mechanisms that may explain the relation between breakfast skipping and school performance. The first one concerned the change in sleep behavior, a shift in circadian rhythm, which takes place in adolescence. Previous studies on the relationship between breakfast skipping and school performance have overlooked this important potential confounder (Hoyland et al., 2009; Rampersaud, 2009). Because of the change in circadian rhythm, adolescents go to bed later and want to get

up later, which means that they shift more toward the evening chronotype (Carskadon, Acebo, & Jenni, 2004; Roenneberg et al., 2004). This may affect breakfast consumption, because adolescents who go to bed later and want to get up later may not have enough time or be hungry enough to eat breakfast (Alexy, Wicher, & Kersting, 2010; Keski-Rahkonen, Viken, Kaprio, Rissanen, & Rose, 2004). Moreover, school performance is affected by lack of sleep, poor sleep quality, and sleepiness (Dewald, Meijer, Oort, Kerkhof, & Bögels, 2010). Thus, the negative relation between breakfast skipping and school performance could be due to chronotype. Therefore, we investigated the role of chronotype in the relation between breakfast skipping and school performance.

Second, we considered a neuropsychological explanation for the relation between breakfast skipping and school performance. Hoyland et al. (2009) suggested that breakfast skipping might lead to reduced attention, which in turn leads to a decrease in school performance. This is in line with results of experimental studies that showed that attention is affected by breakfast skipping (Hoyland et al., 2009; Wesnes, Pincock, Richardson, Helm, & Hails, 2003). Thus, we also investigated whether attention mediates the relationship between breakfast skipping and school performance.

METHOD

Participants

Participants were students from four secondary schools in the south of the Netherlands. They were in grades 7–12. All students were following one of the two advanced educational tracks in Dutch secondary education: the higher general secondary educational level and the more difficult preuniversity educational level. Participants were excluded if they had repeated or skipped a grade after kindergarten, or if they were in a class with students from both the higher general secondary educational level and the preuniversity educational level. Participants were also excluded if data on breakfast consumption, school grades or background variables were missing.

Participation was voluntary. Participants and their parents gave permission for participation by active informed consent. The research protocol was approved by the Ethical Committee of the VU University Amsterdam.

Procedure

The study had a cross-sectional design and was part of a large research project, including multiple research questions. Students were informed about the research project with the help of letters that were distributed by the researchers at the schools. Approximately 2,000 students received a letter, 38% of whom indicated a week later that they were willing to participate. Parents of participating students submitted a completed questionnaire on demographics and the development and behavior of their child. Participating students filled in the questionnaires in the classroom, supervised by two trained psychologists, while nonparticipating students silently worked on an assignment given by the teacher. All questionnaires and tests in the research project took approximately 40 min to complete. The questions for this study took approximately 5 min. All forms were checked following completion, and in case of missing values, participants were asked to complete the items.

Measures

Breakfast Consumption

Breakfast consumption was measured with the question: *Of the 5 school days in a week, how many days do you eat breakfast?* Answers could range from 0 to 5 days. The literature gives multiple definitions of breakfast eaters and breakfast skippers (Rampersaud et al., 2005). We defined breakfast eaters as adolescents who always eat breakfast (score: 5 days). Adolescents who do not eat breakfast every school day were considered breakfast skippers (score: 0–4 days; in the current sample: $M = 2.30$, $SD = 1.40$). Within the group of breakfast skippers, subgroups based on frequency of breakfast skipping did not differ from each other on any of the characteristics mentioned in Table 1 (p-values were between 0.10 and 0.57).

Demographics

Participants reported age, sex, and educational track. Parents reported both parents' educational level. LPE was defined as the highest education of the two. LPE was *low-medium* if the parents had at most a junior vocational educational level and *high* if they had a senior vocational or academic educational level (Kalff et al., 2001).

Chronotype

Chronotype is the natural preference for activity in the morning or evening (morningness/eveningness) and can be considered a continuum (Beşoluk, Önder, & Deveci, 2011; Roenneberg et al., 2004). Commonly, chronotype is quantified by the midpoint of sleep on free days (MSF), as described by Roenneberg et al. This method is based on the assumption that on weekend days (days without obligations), the midpoint of sleep is later in evening chronotypes than morning chronotypes. Yet, adolescents commonly oversleep on weekends to compensate for sleep debt that has accumulated during the schooldays. Therefore, the MSF should be corrected for sleep debt (MSF_{SC}) (Roenneberg et al., 2004). In our study, we used MSF_{SC} as an estimation of chronotype. MSF_{SC} was calculated with the formula described by Roenneberg et al. (see Appendix). Parent reports of adolescents' sleep behavior were used in our calculations. As it is difficult for parents to indicate the exact sleep onset and wake times of their children, we used

Table 1
Characteristics of Breakfast Skippers Versus Breakfast Eaters

Characteristics	*Breakfast skippers (n = 100)*	*Breakfast eaters (n = 505)*	*Test statistic*[a]	*Significance*
Age *M* (*SD*)	15.07 (1.47)	14.76 (1.66)	$F(1, 603) = 2.99$	$p = .084$
Sex			$X^2(1) = 2.36$	$p = .124$
Male (%)	37.0	45.3		
Female (%)	63.0	54.7		
Educational track			$X^2(1) = 0.04$	$p = .849$
Higher general secondary education (%)	44.0	43.0		
Preuniversity education (%)	56.0	57.0		
LPE			$X^2(1) = 3.12$	$p = .077$
Low-medium (%)	41.0	31.9		
High (%)	59.0	68.1		
MSF_{SC} *M* (*SD*) in hh:mm	04:13 (00:56)	03:50 (00:43)	$F(1, 564) = 19.98$	$p < .001$
YSR scale: attention problems *M* (*SD*)	5.97 (3.16)	4.85 (3.27)	$F(1, 603) = 9.90$	$p = .002$
Standardized mean school grade *M* (*SD*)	−0.32 (1.04)	0.06 (0.98)	$F(1, 603) = 12.57$	$p < .001$

Note. LPE = level of parental education; MSF_{SC} = midpoint of sleep on free days corrected for sleep debt; YSR = Youth Self-Report; ANOVA = analysis of variance.
[a]Differences between breakfast skippers and breakfast eaters were tested with one-way ANOVAs and X^2 tests.

bed and rise times instead. Bed and rise times have been used more often to calculate chronotype (e.g., Beşoluk et al., 2011; Fleig & Randler, 2009). Bed and rise times were acquired by asking parents the following questions for both school days and weekends/holidays: *What time does your child usually go to bed? What time does your child usually wake up?* Answers were in hours and minutes.

Attention

Attention was measured with the Attention Problems Scale from the Dutch version of the Youth Self-Report (YSR) (Achenbach & Rescorla, 2001; Verhulst, Van der Ende, & Koot, 1997). The YSR has been validated for adolescents aged 11–18 years. The Attention Problems Scale of the YSR consists of nine items that describe attention problems that may be experienced in daily life, for example, *I am not paying attention or I am easily distracted*. Answers were given on a 3-point scale, 0 = *not true*, 1 = *somewhat or sometimes true*, and 2 = *very true or often true*. The total score was computed by adding up scores of all items. A higher score indicates more self-reported attention problems. Cronbach's α of the attention scale was .75 in the current sample.

School Performance

End of term grades of the school year in which the study was carried out (ranging from 1.0 = *very bad* to 10.0 = *outstanding*) were acquired from the schools' administration, for both participants and their classmates. School performance was measured with the arithmetic mean of the subjects Dutch, mathematics, and English as a foreign language. These are the first three main goals of secondary education in the Netherlands (Ministry of Education, Culture and Science, 2006) and are valid estimators of school performance (Reed, Ouwehand, Van der Elst, Boschloo, & Jolles, 2010). Because the schools in the sample used different grading policies, we assumed that the grades would not be comparable. Therefore, each school's grades were transformed into *z*-scores based on the school's mean grade and its standard deviation. In this way, the distribution of scores was similar for each school. Thus, school performance was measured with the standardized mean grade for Dutch, mathematics, and English as a foreign language.

Analyses

All analyses were performed with Predictive Analytics SoftWare (PASW) 18.0 for Mac. To investigate the relationship between breakfast consumption and school performance, a hierarchical multiple regression analysis was performed with standardized mean grades as outcome measure. The first block consisted of the background variables age, sex, educational track, and LPE; in the second block, breakfast consumption was added; and in the third block, age × breakfast consumption and sex × breakfast consumption were added. To avoid multicollinearity, breakfast consumption, age, and sex were centered around zero before their interaction effects were computed (Rose, Holmbeck, Coakley, & Franks, 2004).

Mediation by attention was examined using methods described by Baron and Kenny (1986). According to these methods, the following four requirements have to be met to indicate mediation in our model: there should be significant relationships (1) between breakfast consumption and school performance; (2) between breakfast consumption and attention; (3) between attention and school performance, while controlling for breakfast consumption; and (4) the relation between breakfast consumption and school performance should decrease, while controlling for attention. The Sobel test can then be used to investigate the significance of the mediation (Baron & Kenny, 1986). Relationship 1 was already investigated in the first analysis

for the primary research question. Relationship 2 was investigated with a multiple regression analysis with breakfast consumption as predictor and attention as outcome measure. Relationships 3 and 4 were investigated in one analysis, with school performance as outcome measure and breakfast consumption and attention as predictors (Baron & Kenny, 1986). To investigate the possible confounding effect of chronotype, the same analyses were performed with chronotype instead of attention, because confounding and mediation are statistically—but not theoretically—similar (MacKinnon, Krull, & Lockwood, 2000). In all these regression analyses, the first block consisted of the background variables age, sex, educational track, and LPE.

RESULTS

A total of 786 adolescents participated in the study. Of these, 104 were excluded because they had repeated or skipped a grade. A total of 38 adolescents were excluded because they were in a class with students from both higher general secondary education level and preuniversity education level, and 39 adolescents were excluded because of missing data on breakfast consumption, school grades, or LPE. The final sample consisted of 605 adolescents, 44% boys and 56% girls, aged 11.75–18.63 years ($M = 14.81$, $SD = 1.64$), of whom 98.0% had the Dutch nationality. LPE was low-medium in 33.4% and high in 66.6% of the participants. Missing responses to items on the YSR were replaced with the average score of the scale for that individual. In total, five responses were missing, never more than one for an individual participant (Tabachnick & Fidell, 2007). When MSF_{SC} could not be calculated due to missing bed or rise times, the case was deleted from the analyses with this variable ($n = 39$). Thus, all analyses were conducted with $N = 605$, except for those concerning chronotype, in which case $N = 566$.

The standardized mean grades of students in the sample were compared with their classmates' grades. Results from a GLM analysis with the independent variables participation, educational track, and grade showed a significant difference (standardized mean grade participants: $M = 0.14$, $SD = 1.02$; standardized mean grade classmates not in sample: $M = -0.07$, $SD = 0.98$; $F(1, 1{,}665) = 11.33$, $p = .001$). However, due to the very small effect size (*partial* $\eta^2 = 0.007$), and the very large N for this analysis ($N = 1{,}676$), it was assumed that the sample was comparable to their classmates with respect to school grades.

Breakfast Skipping

Of the adolescents in the sample, 2.5% skipped breakfast on all school days and 14.0% skipped breakfast on some but not all days of the school week. This means that—according to our definition—16.5% of the adolescents in the sample were considered breakfast skippers, which makes the other 83.5% breakfast eaters. Table 1 shows characteristics of breakfast skippers and breakfast eaters. They were similar with regard to all characteristics, except chronotype, attention, and school performance.

Relationship Between Breakfast Skipping and School Performance

Table 2 shows correlations between the background variables, breakfast consumption, and outcome measures. School performance was related to all variables, except age and MSF_{SC}. Table 3 shows the final model of the multiple regression analyses with school performance as outcome measure. Step 1—with the background variables age, sex, educational track, and LPE—explained 12% of the variance. Sex and educational track were both strongly related to school performance. The direction of the regression coefficients indicated that being a girl and going to preuniversity educational level was associated with higher school grades. The effect of LPE approached significance, with high LPE being associated with higher school grades. Step 2 shows a significant main effect of breakfast consumption: Breakfast skipping was associated with lower school performance. The β indicates that the grades of breakfast skippers were 0.15 standard deviation lower than the grades of breakfast eaters. Converted to school grades and taking into consideration that the standard deviation of school grades varied between schools ($SD = 0.68$–0.87), the school grades of breakfast skippers were at least 0.1 point lower than the school grades of breakfast eaters. This is a meaningful difference, as school grades in Dutch schools are calculated with one decimal. Adding the interaction effects age × breakfast consumption and sex × breakfast consumption to the model in Step 3 did not further increase the predictive value ($\Delta R^2_{(\text{Step 3}-\text{Step 2})} = .00$), as both effects were not significant.

Thus, our study clearly indicated that breakfast skipping and school performance are related: adolescents who skip breakfast had lower grades than breakfast eaters. This relation was similar for younger and older adolescents and did not depend on sex. Still, girls achieved higher grades than boys.

The Role of Sleep

Our study also showed that breakfast consumption and MSF_{SC} were related: breakfast skippers were more often evening chronotypes ($R^2 = .30$; breakfast consumption: $B = -1{,}145.49$, $SE(B) = 264.99$, $\beta = -.15$; $p < .001$). However, there was no relation between MSF_{SC} and school performance ($R^2 = .13$; MSF_{SC}: $B = 0.00$; $SE(B) = 0.00$; $\beta = -.06$; $p =$ ns). Thus, chronotype was not a confounder, because it was related to breakfast consumption but not to school performance.

Table 2
Zero-Order Correlations Between Main Variables

	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
1. Age	—							
2. Sex	.06	—						
3. Educational track	.11**	−.01	—					
4. LPE	−.10*	−.01	.17**	—				
5. Breakfast consumption	−.07	−.06	.01	.07	—			
6. Attention problems	.11**	−.01	−.06	−.07	−.13**	—		
7. MSF_{SC}	.53**	.02	.08	−.05	−.19**	.18**	—	
8. School performance	−.01	.14**	.30**	.13**	.14**	−.23**	−.06	—

Note. LPE = level of parental education; MSF_{SC} = midpoint of sleep on free days corrected for sleep debt.
*$p < .05$. **$p < .01$.

Table 3
The Final Regression Model With School Performance as Outcome Measure

Variable	β	*Significance*
Step 1		
Age	−.04	$p = .303$
Sex	.14	$p < .001$
Educational track	.29	$p < .001$
LPE	.08	$p = .056$
Step 2		
Age	−.03	$p = .415$
Sex	.15	$p < .001$
Educational track	.29	$p < .001$
LPE	.07	$p = .090$
Breakfast consumption	.14	$p < .001$
Step 3		
Age	−.07	$p = .247$
Sex	.18	$p = .001$
Educational track	.29	$p < .001$
LPE	.07	$p = .092$
Breakfast consumption	.15	$p < .001$
Age × breakfast consumption	.05	$p = .411$
Sex × breakfast consumption	−.04	$p = .490$

Note. LPE = level of parental education. $R^2 = .12$ for Step 1, $R^2 = .14$ for Step 2, $R^2 = .14$ for Step 3.

The Role of Attention

Breakfast consumption was related to self-reported attention problems: breakfast skippers reported more attention problems than breakfast eaters ($R^2 = .03$; breakfast consumption: $B = -1.04$; $SE(B) = 0.36$; $\beta = -.12$, $p = .004$). Self-reported attention problems were also related to school performance (corrected for breakfast consumption; $R^2 = .17$; attention problems: $B = -0.06$; $SE(B) = 0.01$; $\beta = -.19$; $p < .001$). In addition, the effect of breakfast skipping on school performance significantly decreased when it was corrected for attention problems ($\Delta\beta = .15 - .12 = .03$). This means that attention partially mediated the relation between breakfast skipping and school performance. The Sobel test showed that this mediation was significant (Sobel test statistic = 2.481; $SE = 0.02$; $p = .013$).

DISCUSSION

The current cross-sectional study on adolescents aged 11–18 showed that habitual breakfast skipping and school performance are related: breakfast skippers performed lower at school compared with breakfast eaters. The advantages of the current study were that—contrary to previous studies—findings were systematically controlled for age, sex, educational track, and LPE. Moreover, the results have high ecological validity, first of all because habitual breakfast skipping was investigated instead of breakfast skipping on one single day or during one particular week, and second, because school performance was measured with end-of-term school grades instead of standardized tests. Results of previous studies are in line with our findings (Edwards et al., 2011; Hoyland et al., 2009; Rampersaud et al., 2005). Those studies also found evidence for a negative relation between breakfast skipping and school performance in both adolescents and children.

No relationship with age was found, indicating that breakfast skipping had a similar relation to performance in younger and older adolescents. Although the glucose metabolism in the brain differs in early versus late adolescence (Chugani, 1998), direct effects of age on the relation between breakfast consumption and performance have not yet been shown (Hoyland et al., 2009). Possibly, age may be confounded by individual differences in brain development. This should be investigated in future research. We also found no sex differences in the relationship between breakfast skipping and performance. However, a previous study by Lien (2007) did find sex differences: breakfast skipping in boys aged 15–16 was more strongly negatively related to performance than breakfast skipping in girls in this age group. This study investigated a more homogeneous sample, consisting of adolescents from two advanced educational tracks. In this way, more external factors were controlled for. This study also covered a broader age range (11–18 years). Thus, the discrepancy between the studies may be due to sample differences.

The research questions regarding chronotype and attention have led to several new insights. Chronotype was related to breakfast skipping: adolescents with an evening chronotype were more prone to skip breakfast. A possible explanation is that adolescents with an evening chronotype want to sleep longer or are not yet hungry in the early morning (Alexy et al., 2010; Keski-Rahkonen et al., 2004). Unexpectedly, chronotype was unrelated to school performance. We had expected to find this relationship, because adolescents with an evening chronotype do not get enough sleep during the week (Crowley, Acebo, & Carskadon, 2007). Short sleep duration has been shown to have a negative relation with school performance, according to a meta-analysis by Dewald et al. (2010). However, based on the current study, it seems that the relation between breakfast skipping and school performance is stronger than the relation between lack of sleep and school performance. This stresses the importance of breakfast for school performance. Future research should further investigate the causal mechanisms between these variables, using objective sleep measures in addition to the more subjective measures as used in the current study. Still, these results suggest that studies on sleep and school performance could benefit from the inclusion of breakfast skipping as a confounder.

In this study, self-reported attention problems partially mediated the relation between breakfast skipping and school performance. This is in line with the hypothesis of Hoyland et al. (2009), which states that breakfast skipping leads to reduced attention, which then affects performance. It is also in accordance with experimental studies, showing that breakfast consumption was related to feelings of alertness (Widenhorn-Müller et al., 2008) and performance on attention tests (Wesnes et al., 2003). However, this study had a cross-sectional design, from which conclusions about causal mechanisms cannot be drawn. To understand the direction of the effect, longitudinal and/or experimental studies need to be conducted, preferably using both self-reported attention measures and objective attention tests. Still, this is, to our knowledge, the first study on habitual breakfast behavior and school performance to establish such a relationship. In addition, future research could investigate other potential mediators, such as memory and executive functions, to identify the exact mechanisms that link breakfast skipping to school performance.

The current study used a homogeneous study sample to better control for education level by only including students from the two highest tracks of Dutch secondary education. Interestingly, a relationship between breakfast skipping and school performance was still found in this sample, although breakfast skipping is less common in this group than in the prevocational education track (Raaijmakers, Bessems, Kremers, & Van Assema, 2010), in which approximately 60% of all students in the Netherlands are placed (Ministry of Education, Culture and Science, 2009). It is therefore likely that the relationship may be even stronger in students in prevocational education, which would be interesting to investigate in further studies. Furthermore, the definition of breakfast skipping we used was based on the adolescents' own interpretation of the word "breakfast." Rampersaud (2009) noted that this could lead to differences in interpretation, which may be a confounder within and between studies. Besides that, we only measured breakfast frequency on schooldays. We did not address breakfast frequency in weekends, nor what and how much was consumed. More accurate measurements and more detailed conclusions could be reached, by taking these factors into account in further research.

To conclude, this study shows that breakfast skipping and school performance are related and that the relation is partially mediated by attention. Breakfast thus seems to be important for school performance, although we cannot draw causal conclusions from the current study. Rampersaud (2009) stated that there are no signs that breakfast consumption is disadvantageous to students. Therefore, it would be sensible to inform adolescents, parents, and teachers about the importance of breakfast as a part of psycho-education and other health interventions.

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APPENDIX

Table A1

Calculation of Midpoint of Sleep on Free Days Corrected for Sleep Debt, Extracted From Roenneberg et al. (2004)

Formula	$MSF_{SC} = MSF - 0.5*(SD_F - [5*SD_W + 2*SD_F]/7)$
In which	MSF_{SC} = midpoint of sleep on free days, corrected for sleep debt
	MSF = midpoint of sleep on free days
	SD_F = sleep duration on free days
	SD_W = sleep duration on work days