



Associations between inhibitory control and body weight in German primary school children



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ABSTRACT

Deficits in inhibitory control are supposed to be a risk factor for overweight but literature concerning childhood and beyond the clinical setting is scarce. The objective of this study was to investigate the role of inhibitory control in regards to body weight in a large non-clinical sample of primary school children. Baseline data of 498 children (1st and 2nd grade; 7.0 ± 0.6 years; 49.8% boys) participating in a school-based intervention study in Germany were used. Children performed a Go-Nogo-task to assess inhibitory control. Height and weight were collected and converted to BMI percentiles based on national standards. Relevant influencing factors (sociodemographic data, health characteristics of parents, children's health behaviour) were assessed via parental questionnaire. Inhibitory control was significantly associated with body weight and contributed to the statistical prediction of body weight above and beyond parent education, migration background, parent weight, TV consumption and breakfast habits. Moreover, obese children displayed significantly lower inhibitory control compared to non-overweight and overweight children. The findings suggest that deficits in inhibitory control constitute a risk factor for paediatric obesity.

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1. Introduction

The increasing prevalence of paediatric obesity in industrialised countries has become a major topic of public health in recent decades. The German Health Interview and Examination Survey for Children and Adolescents (KIGGS) indicates an overweight prevalence of 14.8% with a profound increase at the age of school entry (Kurth & Schaffrath Rosario, 2010). There is a high risk for several chronic diseases (e.g. hypertension, type 2 diabetes, pulmonary and musculoskeletal complications) as well as psychosocial repercussions associated with childhood overweight (Ebbeling, Pawlak, & Ludwig, 2002; Reilly et al., 2003; Schwimmer, Burwinkle, & Varni, 2003). Besides genetic predisposition certain behavioural and lifestyle factors such as unfavourable dietary habits and preferences of sedentary activities have been identified to contribute to excessive weight gain (Nagel et al., 2009; Proctor et al., 2003; Reilly et al., 2005).

Recently, the importance of deficits in self-regulating skills for the development of overweight has been acknowledged. One essential

cognitive regulatory function is inhibitory control defined as the ability to withhold prepotent inappropriate responses (Miyake, Friedman, Emerson, Witzki, & Howerter, 2000; Nigg, 2000). Deficits in inhibitory control are linked to impulsive and less self-controlled behaviour (Barkeley, 1997; Logan, Schachar, & Tannock, 1997; Nederkoorn, Braet, Van Eijs, Tanghe, & Jansen, 2006) and associations between impulsivity respectively self-control and body weight or weight change have been shown previously (Braet, Claus, Verbeken, & Vlierberghe, 2007; Duckworth, Tsukayama, & Geier, 2010; Nederkoorn, Jansen, Mulken, & Jansen, 2006). Further, numerous studies are indicating a comorbidity between attention deficit / hyperactivity disorder (ADHD) and obesity (Cortese et al., 2008). As one explanation a deficient inhibitory control and delay aversion in ADHD leading to unusual eating behaviours are discussed (Cortese et al., 2008; Davis, Levitan, Smith, Tweed, & Curtis, 2006). The direct role of inhibitory control in regards to body weight and weight status has been shown in preschool as well as in school children (Graziano, Calkins, & Keane, 2010; Pauli-Pott, Albayrak, Hebebrand, & Pott, 2010). Pauli-Pott et al. found significant interactions with age showing this link exclusively in younger school children and assumed an especially important developmental period around the age of 8 years.

Regarding the underlying mechanisms researchers assume that maladaptive eating behaviour (e.g. overeating, impulsive eating) may play a role (Davis et al., 2006; Graziano et al., 2010). Children with low impulse control are more vulnerable for food temptations, seek

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immediate gratification, fail to think their responses through and tend to overeat (Jansen et al., 2003; Nederkoorn, Jansen, et al., 2006). Riggs, Chou, Spruijt-Metz, and Pentz (2010) pointed out the importance of inhibitory control and further executive functions in planning, implementing and maintaining healthy goal-directed behaviour including food intake and physical activity.

Nevertheless, there is a lack of research especially for children in early school age when excessive weight gain is particularly pronounced and great progress in self-regulating skills are made. Studies predominantly examined clinical populations who possibly suffer more intense impulsivity problems, comorbid psychopathology or extreme weight problems and sample sizes are often limited. The objective of the present study was to investigate directly the role of inhibitory control in body weight and in the development of weight problems in a large non-clinical sample of primary school children. The continuous spectrum of body weight was considered as well as the classification in clinically meaningful weight groups. Putative confounders (sociodemographic features, parent weight, children's health behaviour) were taken into account. It was hypothesised that inhibitory control contributes significantly to the prediction of body weight and that children with poorer inhibitory control are more likely to be overweight or obese.

2. Material and methods

2.1. Overview

The study was conducted within the context of the Baden-Württemberg Study which is evaluating the effects of a school-based health promotion programme for children implemented in southwest Germany. The Baden-Württemberg Study was approved by the institutional ethics committee and is registered at the German Clinical Trials Register (DRKS0000494). A detailed description has been published elsewhere (Dreyhaupt et al., 2012). Teachers volunteered to participate and written informed consent was obtained from parents. Baseline measurements including the assessment of anthropometric and cognitive data were taken in autumn 2010. All measurements were performed on site at school. After the measuring period a parental questionnaire was issued and returned within six weeks.

2.2. Participants

Overall, $n = 498$ children from ethnically and socioeconomically diverse primary schools in the federal state of Baden-Württemberg, Germany, provided anthropometric and cognitive data. Children attended 1st grade (57.0%) or 2nd grade and averaged 7.0 ± 0.6 years of age; 49.8% were boys. Exclusion criteria were colour blindness and motor impairments.

2.3. Cognitive measures

Inhibitory control was measured via the Go-Nogo-task of the computer-based test battery of attention for children (KiTAP; Zimmermann, Gondan, & Fimm, 2002). The KiTAP is valid for the age range 6 to 10 years and has been used in paediatric, basic and cross-cultural research (Drechsler, Rizzo, & Steinhausen, 2009; Eikelmann, Petermann, & Daseking, 2008; Kaller, Langguth, Ganschow, Nashan, & Schulz, 2010; Sobeh & Spijkers, 2013; Trautmann & Zepf, 2012). The test was administered during the first school hours by trained examiners in small groups; instructions were standardised. Comprehension and willingness of the children were assured by short preceding practice trials.

A total score based on number of errors and reaction time was calculated (errors standard scores minus reaction time standard scores) and reversed to improve interpretability. A positive total score therefore indicates high inhibitory control (less number of errors; slower, more

reflexive reactions), a negative score low inhibitory control (higher number of errors; faster, more impulsive reactions).

2.4. Anthropometric measures

Height and weight of the children were taken by trained staff according to the guidelines of the International Society for the Advancement of Kinanthropometry (ISAK; Marfell-Jones, Olds, Stewart, & Carter, 2006). Children's body mass index (BMI) was calculated (kg / m^2) and converted to BMI percentiles using national age- and sex-specific reference data (Kromeyer-Hauschild et al., 2001). Subjects were categorized as overweight (>90 th percentile, ≤ 97 th percentile), obese (>97 th percentile) and non-overweight (≤ 90 th percentile).

2.5. Co-variables

Sociodemographic data, health characteristics of parents and children's health behaviour were assessed via parental questionnaire. Parent education was assigned according to the CASMIN classification (Brauns, Scherer, & Steinmann, 2003). Due to the small number of cases with primary education level parent education was dichotomised with primary and secondary versus tertiary education level. Migration background was defined as at least one parent born abroad or mainly having spoken a foreign language with the child during its first years of life. Self reported parental height and weight were used to calculate BMI of mother and father. Additionally, parents estimated their child's TV consumption and breakfast habits. The mean time spent watching television per day was dichotomised using a cut-off-point at 1 h as the American Academy of Paediatrics (2001) recommends less than 1 – 2 h of screen time per day. For statistical analysis frequency of having breakfast prior to going to school was also dichotomised with “never” / “rarely” versus “often” / “always”.

2.6. Statistical methods

Hierarchical multiple regression analysis was performed to determine the predictive value of inhibitory control on BMI percentiles controlling for potential confounders. To determine whether children with poorer inhibitory control are more likely to have weight problems ANOVA and Tukey-HSD post-hoc analysis across different weight groups were used. Due to incomplete data sample size varies for different analyses. Statistical analyses were carried out using SPSS 19, statistical significance was set at $\alpha = 0.05$.

3. Results

Inhibitory control of children averaged -0.01 ± 1.68 (total score), with a mean number of errors of 5.28 ± 3.26 and a mean reaction time of $511.14 \text{ ms} \pm 76.34 \text{ ms}$. Average BMI percentile of children was 48.21 ± 26.92 and 8.4% were classified as overweight or obese. Average BMI of mothers was 23.86 ± 4.47 , BMI of fathers 27.90 ± 3.93 . Sociodemographic, behavioural and further weight group characteristics are shown in Table 1.

Results of the hierarchical regression are presented in Table 2. Model 1 was established including parent education, migration background, BMI of mother and father, children's TV consumption and breakfast habits as co-variables. In Model 2 inhibitory control was added and contributed significantly to the prediction of BMI percentiles.

Furthermore, there was a significant difference in inhibitory control between weight groups ($F(2, 474) = 6.46, p = .002, \eta^2 = .03$) with a significant lower total score in obese children compared to non-overweight ($MD = 1.52, SE = 0.42, p = .001$) and overweight children ($MD = 1.39, SE = 0.54, p = .027$). Overweight children did not differ significantly from non-overweight children. Obese children showed more errors than the other two groups ($F(2, 27.95) = 5.09, p = .013, \eta^2 = .03; MD = 3.05, SE = 1.15, p = .05$ and $MD = 3.33, SE = 1.28, p = .04$).

Table 1
Descriptive characteristics of the total sample.

	n	%
Sex		
Female	250	50.2
Male	248	49.8
Parent education ^a		
Primary level	4	1.0
Secondary level	266	63.6
Tertiary level	148	35.4
Migration background ^b	156	36.4
TV consumption > 60 min ^c	65	14.9
Breakfast habits ^d		
Never / rarely breakfast	60	13.6
Weight group ^e		
Non-overweight	454	91.5
Overweight	25	5.0
Obese	17	3.4

Due to incomplete data sample size is varying. Information available for ^a n = 418; ^b n = 428; ^c n = 437; ^d n = 440; ^e n = 496.

and the shortest reaction time, just failing significance level compared to non-overweight children ($F(2, 474) = 3.12, p = .045, \eta^2 = .01; MD = 44.77, SE = 19.39, p = .06$).

4. Discussion

In a sample of primary school children inhibitory control contributed significantly (1.4% additional variance accounted) to the statistical prediction of body weight above and beyond parent education, migration background, parent weight, children's TV consumption and breakfast habits. Considering that BMI is a complex construct influenced by multiple genetic, behavioural and environmental factors this can be interpreted as a distinct contribution of inhibitory control. Previous studies reported similar values (2%; Pauli-Pott et al., 2010). In infants Graziano et al. (2010) found larger ones for inhibitory control in terms of reward sensitivity (8%) but only controlled for behavioural problems.

Comparing weight groups only obese but not overweight children showed poorer inhibitory control compared to non-overweight children. The more impulsive responses could be seen in the highest error rate as well as the shortest reaction time supporting previous findings of higher impulsivity in obese children (Braet et al., 2007; Nederkoorn, Jansen, et al., 2006). Of particular interest is the finding that the effect was limited only to the obese suggesting that inhibition plays a role especially in extreme overweight. As in most studies only two weight groups are compared, further research is needed to confirm this assumption. There might even be a critical cut-off-point from which inhibitory control gets relevant for body weight.

Table 2
Results of two linear regression models predicting children's body weight from different influencing factors with and without inhibitory control.

Predictors	BMI percentiles		
	Model 1	Model 2	
	B	B	95% CI
Parent education	−4.26	−3.80	[−9.45, 1.86]
Migration background	4.01	3.53	[−2.44, 9.50]
BMI mother	1.11***	1.03**	[0.45, 1.62]
BMI father	1.02**	1.05**	[0.37, 1.73]
TV consumption	3.86	2.26	[−5.92, 10.45]
Breakfast habits	2.51	2.53	[−5.81, 10.86]
Inhibitory control		−1.91*	[−3.52, −0.29]
R ²	.11	.12	
F	6.63***	6.53***	
ΔR ²		.01	
ΔF ²		5.37*	

Note. N = 340. CI = confidence interval. * p < .05; ** p < .01; *** p < .001.

It should be noted that the cross-sectional study design precludes any causal interpretation of the findings. Besides the assumption that inhibitory control influences healthy (eating) behaviour and therefore body weight the relationship could be reverse or bidirectional as well. Variations in food intake or physical activity could also influence cognitive functions and brain development (Riggs et al., 2010). Further, the low number of obese children did not allow controlling for potentially confounding variables in the weight group comparison. Conclusions on inhibitory control in obese children must be drawn carefully and further analyses such as the identification of potential subgroups are needed. Taking BMI percentiles as measure for children's body weight might not reflect actual body fat content. However, it is an accepted measure for population research, clinically meaningful (Reilly et al., 2003) and enables comparability with other studies. Regarding the behavioural aspects assessed via parental questionnaire underreporting in terms of social desirability should be taken into account. The objective standardised measurements of cognitive and anthropometric data, however, can be considered as strength of the study.

The current findings provide support for an association between inhibitory control and body weight in children entering primary school and suggest that paediatric obesity is linked to poorer inhibitory abilities. Further work is needed to clarify the direction and underlying mechanisms. In addition, other cognitive functions and self-regulating skills should be considered to prove whether this link is specific to inhibition processes. As an implication obesity intervention and prevention should also consider cognitive regulation of health behaviour and include for example measures to strengthen inhibition of impulsive eating (e.g. perception of satiation, resistance for food temptations, prevention of overeating) as well as changes in environment for those with poorer inhibition.

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Contributors

Tamara Wirt designed the study and wrote the first draft of the manuscript. Verena Hundsdörfer, Anja Schreiber, and Dorothea Keszytüs were involved in statistical analysis and revising the manuscript. Jürgen M. Steinacker is the principal investigator of the Baden-Württemberg Study and director of the programme "Komm mit in das gesunde Boot – Grundschule". Tamara Wirt, Verena Hundsdörfer, Anja Schreiber, Dorothea Keszytüs, and the research team organised the Baden-Württemberg Study and were involved in carrying out the measurements. All authors contributed to and have approved the final manuscript.

Conflict of interest

All authors declare that they have no conflicts of interest.

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