Soft Drink Consumption and Mental Health Problems: Longitudinal Relations in Children and Adolescents

Philipp Kadel

Health Psychology, Department of Social Sciences, University of Mannheim, Germany

Sven Schneider

Mannheim Institute for Public Health, Social and Preventive Medicine, Heidelberg University, Germany

Jutta Mata

Health Psychology, Department of Social Sciences, University of Mannheim, Germany

Author Note

Correspondence concerning this article should be addressed to Philipp Kadel, University of Mannheim, Health Psychology, L13, 17, 68131 Mannheim, Germany. E-mail: kadel@uni-mannheim.de

Acknowledgements: We are grateful to the Robert Koch Institute in Berlin, Germany, for providing the data and to Anita Todd for editing the manuscript. This study was presented at the 33rd Conference of the European Health Psychology Society (EHPS), September 2019, Dubrovnik, Croatia and the 14th Congress of the Division of Health Psychology of the German Society for Psychology (DGPs), September 2019, Greifswald, Germany.

None of the authors declare a conflict of interest.

Abstract

Background: Increased soft drink consumption has been proposed as both predictor and result of mental health problems. Although possible mechanisms for both directions have been suggested, understanding of the association is limited. Most previous research has been cross-sectional and could not assess directionality.

Methods: This study investigated the directionality of the association between soft drink consumption and mental health using longitudinal panel data of $N = 5{,}882$ children and adolescents from the nationally representative German KiGGS baseline study (2003–2006) and KiGGS Wave 1 (2009–2012). Soft drink consumption and mental health problems were assessed by standardized questionnaire (baseline) and telephone interview (Wave 1). Four cross-lagged panel models were specified and compared regarding their fit indices. Specific paths were tested for significance.

Results: Positive cross-sectional associations between soft drink consumption and mental health problems were found at both measurement points ($ps < .01$), even after controlling for third variables (including age, gender, and socioeconomic status). Only the lagged effect of mental health problems on soft drink consumption reached statistical significance ($\beta = .031$, $p = .020$), but not vice versa. The corresponding model also showed the best model fit overall.

Conclusions: Mental health problems predicted soft drink consumption over an average of six years, but not vice versa. These findings suggest that consuming soft drinks might be a dysfunctional strategy for coping with mental health problems for children and adolescents and highlight the importance of considering mental health problems in the prevention of soft drink overconsumption and obesity.

Keywords: soft drinks, soda, mental health, coping, child health, adolescents

This study was preregistered using the Open Science Framework (OSF): https://osf.io/5798y/

Introduction

The consumption of soft drinks is considered a major risk factor for the development of widespread noncommunicable diseases such as obesity, Type 2 diabetes, and dental caries (see Vartanian et al., 2007, for a meta-analysis). Importantly, it is also associated with mental health problems (e.g., Hu et al., 2019). Previous studies have suggested increased soft drink consumption as both predictor and result of various mental health problems. As the majority of research on this association is cross-sectional, its directionality remains unclear. The current study addresses this gap with an investigation of the association of mental health problems, which for this study were defined as problems regarding emotion, conduct, peers, and hyperactivity (Goodman and Goodman, 2009), and soft drink consumption in longitudinal data on children and adolescents. In the following, empirical findings and potential mechanisms from previous literature are presented for both directions.

Soft Drink Consumption as a Predictor of Mental Health Problems

Several studies, including two recent meta-analyses, concluded that the consumption of soft drinks might be linked to an increased risk of depression, but further research, especially using prospective designs, is needed (Hu et al., 2019; Kang et al., 2018). Two prospective studies found that increased soft drink consumption (Guo et al., 2014; Sanchez-Villegas et al., 2018) as well as sugar consumption in general (Knüppel et al., 2017) are associated with risk of depression among adults. Cross-sectional studies showed similar findings in children and adolescents: Soft drink consumption was linked to mental distress, conduct problems, and total mental health difficulties in 5,498 10th-grade students in Norway (Lien et al., 2006). Bruckauf and Walsh (2018) showed an association of sugar consumption, especially soft drinks, and violent behavior, that is, bullying and fighting in adolescents.

The understanding of mechanisms underlying the effect of soft drink consumption on mental health problems is limited (Bruckauf and Walsh, 2018). Proposed mechanisms are

mainly biological. Sweet taste has been shown to alter levels of β-endorphins in animal studies (Yamamoto et al., 2000). This opioid's role in the pathophysiology of depression is supported by animal studies and research in clinical populations (Hegadoren et al., 2009). Furthermore, sugar is also suspected to impact oxidative stress and foster inflammatory processes, which are both linked to depression (Westover and Marangell, 2002). Likewise, a heightened consumption of sugar contributes to the development of insulin resistance (Palanker Musselman et al., 2011), which is also associated with elevated depressive symptoms (Timonen et al., 2005). Moreover, some soft drinks such as cola and iced tea contain caffeine, which has been suspected to be a potential mediator for their effect on behavior problems, such as aggressive behavior in children (Suglia et al., 2013).

Soft Drink Consumption as a Result of Mental Health Problems

At the same time, several cross-sectional studies have suggested increased soft drink consumption as a result of mental health problems. Posttraumatic stress disorder symptoms were related to increased soft drink consumption in young women in the United States (Hirth et al., 2011) and 8th-grade students in Lithuania (Vilija and Romualdas, 2014). Other studies found that exposure to violence (Piontak et al., 2017) and being bullied, threatened, or injured in school (Park et al., 2013) were linked to a higher intake of unhealthy beverages, including soft drinks.

The effect of mental health problems on the consumption of soft drinks might be best explained by seeing soft drink consumption as a strategy for coping with unpleasant symptoms of mental health problems (Vilija and Romualdas, 2014), particularly in children and adolescents, who do not have access to other substances such as alcohol, nicotine, or illicit drugs such as cannabis. Sugar has been shown to have analgesic effects (Blass and Hoffmeyer, 1991) and thus could numb unpleasant feelings. Sugar also activates a metabolic brain feedback pathway, which may turn off stress responses (Tryon et al., 2015). Moreover,

sugar stimulates the brain's reward system (Koekkoek et al., 2017), which may also foster its use for coping with unpleasant symptoms of mental health problems. Ulrich-Lai (2016) even referred to the consumption of sucrose as a way of self-medication in response to stress. In children, positive emotional associations with soft drinks (Geers et al., 2017) as well as stress (Michels et al., 2015), negative affect, and low momentary ability to cope (Mason et al., 2019) have been shown to predict higher soft drink consumption. Additionally, soft drinks might be used as a coping strategy not only by children themselves but—especially in younger children—also by parents to attenuate mental health problems in their offspring. In hospitals, sucrose is given to infants as an analgesic (Blass and Hoffmeyer, 1991).

Sociodemographic Predictors of Soft Drink Consumption and Mental Health Problems

Previous research has shown that several sociodemographic variables are important in the context of soft drink consumption and mental health problems in children and adolescents: Male gender, older age, and lower socioeconomic status (SES) are all positively related to both soft drink consumption (e.g., Mensink et al., 2018; Fielding-Singh and Wang, 2017) and mental health problems (Klipker et al., 2018; Reiss, 2013) in children and adolescents. Further, migration background has been linked to soft drink consumption, with children with a migration background showing higher consumption (e.g., Hasselkvist et al., 2014). All of the above factors were considered in the current study as control variables.

Research Goals and Hypotheses

Most previous research on the association between mental health problems and soft drink consumption has been cross-sectional and thus could not assess directionality. The three available prospective studies all focused on depression in adults (Guo et al., 2014; Knüppel et al., 2017; Sanchez-Villegas et al., 2018); two tested only one direction of the effect (Guo et al., 2014; Sanchez-Villegas et al., 2018), and one did not investigate soft drinks but rather sugar in general (Knüppel et al., 2017). Thus, the main goal of the current study was to

investigate the unclear directionality of the association between mental health problems and soft drink consumption using longitudinal data from two waves of a large, representative German panel study. Studying soft drink consumption and mental health is particularly relevant in adolescents in Germany, because they consume more calories from beverages, particularly from soft drinks, than adolescents in many other European countries (cf. the Healthy Lifestyle in Europe by Nutrition in Adolescence study, conducted in Austria, Belgium, France, Germany, Greece, Italy, Spain, and Sweden; Duffey et al., 2012).

Four main hypotheses were derived from the literature described above:

Hypothesis 1 (H1): Mental health problems and soft drink consumption are positively associated at both measurement points (Time 1 and Time 2).

Hypothesis 2 (H2): Mental health problems at Time 1 predict soft drink consumption at Time 2. *H2a:* The model that includes a path from mental health problems at Time 1 to soft drink consumption at Time 2 shows a better fit than the Baseline Model (that includes only the cross-sectional associations at both measurement points and the autoregressive effects). *H2b:* The estimated coefficient for the path from mental health problems at Time 1 to soft drink consumption at Time 2 is positive.

Hypothesis 3 (H3): Soft drink consumption at Time 1 predicts mental health problems at Time 2. *H3a:* The model that includes a path from soft drink consumption at Time 1 to mental health problems at Time 2 shows a better fit than the Baseline Model. *H3b:* The estimated coefficient for the path from soft drink consumption at Time 1 to mental health problems at Time 2 is positive.

Hypothesis 4 (H4): The relationship between mental health problems and soft drink consumption is reciprocal. *H4a:* The model that includes both cross-lagged paths shows a better fit than the Baseline Model and the models that include only one of the lagged paths. *H4b:* The estimated coefficients for both cross-lagged paths are positive.

Importantly, H2 to H4 are not contradictive: H4 is a combination of H2 and H3. If the effect is reciprocal, all hypotheses should be supported by the results. If the effect is unidirectional, either H2 or H3 should be supported.

Exploratory Research Questions

Besides these hypotheses, three exploratory research questions were investigated. The focus of this study was on general mental health problems. However, whether specific subdimensions of mental health problems (i.e., emotional symptoms, conduct problems, hyperactivity, and peer problems; Goodman and Goodman, 2009) show a stronger association with soft drink consumption was also explored. Further, social support was exploratively investigated as a potential moderator for the effect of mental health problems on soft drink consumption. Social support has been shown not only to buffer negative effects of stress (Steptoe, 2000; Stein and Smith, 2015) but also to function as coping assistance (Thoits, 1986). Consequently, higher levels of social support might be an alternative or additional coping strategy to soft drink consumption and are thus assumed to attenuate the relation between soft drinks and mental health. During childhood and adolescence, many developmental processes take place that come with personal, social, and intellectual changes (Elkind, 1994). To investigate how these processes affect the association of soft drink consumption and mental health problems is beyond the scope of this article. However, in an additional exploratory analysis, this study investigated potential differences between age groups as a proxy for different developmental stages. Because there is no clear consensus on what age groups represent different developmental stages in children, for this study, age groups were categorized in seven distinct ways (e.g., 3- to 7-year-olds vs. 8- to 12-year-olds; 3- to 5-year-olds vs. 6- to 9-year-olds vs. 10- to 12-year-olds). Results were then compared between the different age-group categorizations.

Methods

Data

Data were taken from the first two waves of the German Health Interview and Examination Survey for Children and Adolescents (KiGGS), a nationally representative long-term study on health of children and adolescents in Germany carried out by the Robert Koch Institute (Hölling et al., 2012). Data of the KiGGS study are available for scientific use upon request. The KiGGS baseline study ran from May 2003 to May 2006 and included 17,641 children and adolescents between 0 and 17 years and their parents. Parents answered questionnaires about physical, psychological, and social aspects of their children's health. Children and adolescents older than 11 years additionally answered questionnaires themselves. To ensure representativeness, a stratified multistage probability sample was drawn via a two-step procedure; response rate was 66.6% (see Kamtsiuris et al., 2007, for details). The first follow-up (KiGGS Wave 1) was carried out between June 2009 and June 2012 as a telephone-based survey (see Lange et al., 2014, for details). Of the 17,641 participants of the baseline study, 11,992 participated in Wave 1. Of these 11,992 participants, 5,420 were excluded because they were younger than 3 or older than 18 years in Wave 1. In accordance with the study protocol, mental health was not assessed in these age groups. Of the remaining 6,572 participants, another 690 were excluded due to missing data on soft drink consumption, mental health problems, SES, and/or migration background. Missing data were handled using the most conservative option, listwise deletion. This is in line with available guidelines and has the advantage of not further increasing the computational complexity of our analyses (Cheema, 2014). Given that our sample was large even after exclusion of incomplete cases, there was no need to use imputation to increase the power of our analyses. The final sample thus consisted of $N = 5{,}882$ children and adolescents. For the

exploratory analyses including social support, only 581 participants were analyzed, because social support was measured only in children and adolescents aged 11 years or older.

Measures

For all measures, self-report data from children and adolescents were used when available. Parent reports were used when children were younger than 11 years.

Soft drink consumption was measured with two items on frequency and average portion size when consuming soft drinks in the baseline study. Frequency was assessed with "How often during the past weeks did your child/did you drink soft drinks (such as cola, lemonade, iced tea, or malt beer)?" on a 10-point scale ranging from "never" to "more than 5 times a day." Portion size was measured with "When your child drinks/you drink soft drinks, how much does your child/do you usually drink?" Possible answers were "¼ glass (or less)," "½ glass," "1 glass (200 ml)," "2 glasses," and "3 glasses (or more)." In KiGGS Wave 1, the frequency of soft drink consumption was assessed with a similar question but different categories: "daily," "not daily but at least once a week," "less often than once a week," and "never" (Mensink et al., 2018). Only when participants answered "daily" or "not daily but at least once a week" were they asked about the number of soft drinks they or their children drank per day or per week, depending on their previous answer. For both waves, number of consumed glasses of soft drinks per day was computed for each child or adolescent.

Mental health problems were assessed using the German version of the Strength and Difficulties Questionnaire (SDQ; Goodman, 1997), which is one of the most commonly used measures of mental health problems in children (Reiss, 2013) and highly correlates with other established measures of mental health in children (Goodman, 1997). The SDQ consists of 25 items with a 3-point answer scale labeled "not true," "somewhat true," and "certainly true." The items form five subscales: (1) emotional symptoms (Cronbach's alpha in our study: α_{t1} = .62; α_{t2} = .65), (2) conduct problems (α_{t1} = .49; α_{t2} = .44), (3) hyperactivity (α_{t1} = .76; α_{t2}

= .69), (4) peer problems (α_{t1} = .58; α_{t2} = .51), and (5) prosocial behavior (which is not part of the total difficulties score and was thus not included in the analyses). Exemplary items include "I am often unhappy, depressed, or tearful" (emotional symptoms) and "Other people pick on me or bully me" (peer problems). The sum of the first four subscales forms a total difficulties score (α_{t1} = .79; α_{t2} = .75). This established score was used as indicator of children's and adolescents' mental health problems.

Social support was measured with a German translation of the Social Support Scale (Donald and Ware, 1984) and administered only for children and adolescents aged 11 years or above (Cronbach's alpha in our study: α_{t1} = .87). The eight items asked how often support was provided to the children or adolescents, for example, by listening, showing affection, or giving valuable information for problem solving. Items were answered on a 5-point frequency scale from "never" to "always."

Several *control variables* were measured. Age in years was computed from the date of birth assessed at baseline. Gender was assessed in the baseline study by self- or parent report. In the KiGGS study, migration background was established based on the children's and adolescents' country of birth and, when applicable, that of their parents, as well as their parents' nationality (see Frank et al., 2018, for details). When one parent was not born in Germany or did not have German citizenship, children and adolescents were categorized as having a one-sided migration background (Frank et al., 2018). The migration background was defined as two-sided when children or adolescents had migrated to Germany themselves and had at least one parent who was not born in Germany. Children and adolescents with both parents born outside of Germany were also included in this category. SES was determined by parents' reports on their education, occupational status, and income (Lampert et al., 2014). Higher values on the SES score indicate a higher socioeconomic status. Only sociodemographic variables were used as control variables, because they are likely to

confound the association between soft drink consumption and mental health problems. Behavioral variables might rather be seen as intervening variables or outcomes of either soft drink consumption or mental health problems and were thus not included as control variables.

Statistical Analysis

The data were analyzed using a cross-lagged panel approach. Cross-lagged panel analysis falls under the broader category of structural equation modeling (Kuiper and Ryan, 2018) and allows testing the stability of constructs, their cross-sectional associations, and longitudinal effects simultaneously (Kearney, 2017). It is widely seen as the most appropriate method for studying causality in longitudinal data (Kuiper and Ryan, 2018). The analysis is called "cross" because it estimates the effect of one variable on another and vice versa in one model (Kearney, 2017). It is called "lagged" because the effects are modeled across different measurement points.

Four different models were specified (see Figure 1). The Baseline Model included only the cross-sectional associations of mental health problems and soft drink consumption and their autoregressive effects. The Unidirectional Model 1 added the lagged effect of mental health problems on soft drink consumption, whereas the Unidirectional Model 2 included the lagged effect in the other direction. The Reciprocal Model contained both lagged effects. Mental health problems and soft drink consumption were controlled for age, gender, migration background, and SES at both measurement points.

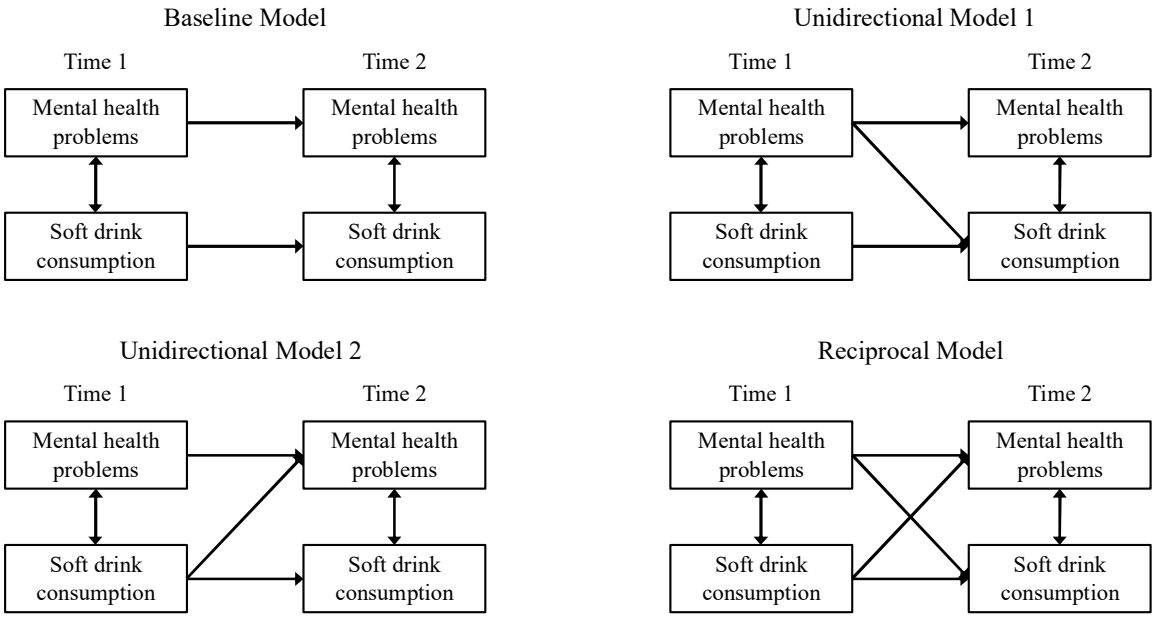

Figure 1. Simplified versions of the four models that were specified in the analysis. The full models additionally contained effects of the control variables age, gender, migration background, and socioeconomic status on soft drink consumption and mental health problems at both measurement points. The cross-sectional associations were specified with regard to the residual variances of soft drink consumption and mental health problems.

As indicators of model fit, the models' chi-square values were used. Traditionally, a nonsignificant chi-square value is assumed to indicate a good model fit (Hu and Bentler, 1995). However, the chi-square value has been shown to be sensitive to sample size and thus nearly always rejects the tested model when large sample sizes are used (Bentler and Bonett, 1980). Hence, the root mean square error of approximation (RMSEA), which should be lower than 0.05 (Browne and Cudeck, 1993), the standardized root mean square residual (SRMR), which should also be less than 0.05 (Hu and Bentler, 1995), and the comparative fit index (CFI), for which values above 0.95 indicate a good model fit (Hu and Bentler, 1995), were also considered. These indices were used to assess the fit of the models themselves and to compare the models regarding their model fit to test H2a, H3a, and H4a. For the comparison

of nested models, chi-square difference tests were used. Additionally, the Akaike information criterion (AIC) and the Bayesian information criterion (BIC) are reported, for which smaller values indicate a comparatively better model fit. The parameters within the models were tested for significance with a predefined significance level of $\alpha = .05$.

For exploratory purposes, a version of the Reciprocal Model was specified in which the participants' scores on the four subscales of the SDQ, namely, emotional symptoms, conduct problems, hyperactivity, and peer problems, were used separately. The control variables were also included in this model, predicting soft drink consumption and all subdimensions of the SDQ at both measurement points. Furthermore, social support was investigated as a potential moderator for the effect of mental health problems on soft drink consumption. For that, the standardized interaction term of mental health problems and social support at Time 1 was added to the Reciprocal Model. A path from this interaction term to soft drink consumption at Time 2 was specified. Social support itself at Time 1 was also added to the model as a standardized predictor of soft drink consumption at Time 2. For this model, mental health problems were also standardized to minimize collinearity with the interaction term. Multigroup analyses were conducted to investigate potential differences between age groups regarding the estimated model parameters. The analyses were run for a total of seven age-categorization variants (see Table S1 in the Supplemental Materials for details). The computation of the indices and descriptive analyses were done in SPSS version 25.0.0.1. The cross-lagged panel analyses were conducted using R version 3.5.2 and the lavaan package version 0.6-3 (Rosseel, 2012). Robust maximum likelihood estimation was used, which adjusts test statistics and standard errors of parameter estimates for biases caused by nonnormality with a correction introduced by Satorra and Bentler (1994).

Results

Descriptive Analyses

The average consumption of soft drinks was just below one glass per day. Table 1 shows the descriptive statistics of all variables analyzed. Soft drink consumption and mental health problems were positively and significantly associated at both measurement points. With the exception of emotional symptoms at Time 2, soft drink consumption was also positively and significantly associated with the subdimensions of mental health problems at both measurement points. Table 2 contains the bivariate correlations of the variables analyzed in this study.

Table 1.

Descriptive Statistics of Analyzed Variables

	Time 1			Time 2		
Variable	*M* or %	*SD*	Range	*M* or %	*SD*	Range
Soft drink consumption	0.89	2.14	0–15	0.95	1.82	0–20
Mental health problems	8.06	4.84	0–32	9.03	4.56	0–31
Age in years	6.96	2.54	3–12	13.04	2.54	8–17
Gender						
Female	49.6%			49.6%		
Male	50.4%			50.4%		
Socioeconomic status	12.45	3.68	3–21	12.90	3.56	3–21
Migration background						
None	85.1%			85.8%		
One-sided	6.7%			6.0%		
Two-sided	8.2%			8.2%		
Social support	76.63	18.89	9–100			
Emotional symptoms	1.72	1.71	0–10	2.26	1.88	0–10
Conduct problems	1.85	1.44	0–10	1.66	1.31	0–10

	Time 1			Time 2		
Hyperactivity	3.21	2.24	0–10	3.50	2.01	0–10
Peer problems	1.27	1.51	0–10	1.62	1.41	0–10

Note. Based on the full sample of N = 5,882, except for social support for which the sample size was n = 581. For categorical variables the shares are shown as percentages.

Table 2.

Correlations of Analyzed Variables at Both Measurement Points

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Time 1																				
1. Soft drink consumption	–																			
2. Mental health problems	.11**	–																		
3. Age in years	.15**	.05**	–																	
4. Gender	-.03	-.10**	.00	–																
5. Socioeconomic status	-.20**	-.22**	-.03*	.01	–															
6. Migration background	.03*	.08**	.02	-.03*	-.17**	–														
7. Social support	.03	-.25**	.03	.16**	.12**	-.02	–													
8. Emotional symptoms	.08**	.67**	.10**	.05**	-.11**	.02	-.07	–												
9. Conduct problems	.06**	.70**	-.07**	-.10**	-.12**	.04**	-.22**	.29**	–											
10. Hyperactivity	.08**	.77**	.01	-.13**	-.20**	.04**	-.17**	.27**	.45**	–										
11. Peer problems	.07**	.64**	.09**	-.09**	-.16**	.14**	-.26**	.34**	.30**	.26**	–									
Time 2																				
12. Soft drink consumption	.24**	.10**	.18**	-.14**	-.18**	-.01	-.10*	.04**	.05**	.11**	.06**	–								
13. Mental health problems	.04**	.30**	.05**	.05**	-.14**	.04**	-.07	.19**	.20**	.27**	.17**	.10**	–							
14. Age in years	.15**	.04**	.99**	.00	-.03*	.02	-.04	.09**	-.07**	.01	.09**	.18**	.05**	–						
15. Socioeconomic status	-.21**	-.22**	-.08**	.01	.80**	-.16**	.11**	-.11**	-.12**	-.20**	-.17**	-.18**	-.15**	-.08**	–					
16. Migration background	.02	.08**	.01	-.03*	-.16**	.96**	-.02	.03*	.03*	.04**	.13**	-.01	.04**	.01	-.15**	–				
17. Emotional symptoms	.02	.16**	.09**	.24**	-.07**	.02	.03	.23**	.06**	.08**	.09**	.02	.71**	.09**	-.08**	.02	–			
18. Conduct problems	.02	.22**	-.09**	-.07**	-.09**	.05**	-.08	.07**	.24**	.19**	.09**	.09**	.64**	-.09**	-.11**	.05**	.26**	–		
19. Hyperactivity	.03*	.24**	.01	-.04**	-.10**	.02	-.03	.08**	.16**	.30**	.07**	.09**	.75**	.01	-.10**	.02	.28**	.40**	–	
20. Peer problems	.04**	.21**	.09**	-.04**	-.11**	.04**	-.16**	.12**	.10**	.14**	.24**	.06**	.58**	.09**	-.12**	.04**	.31**	.21**	.18**	–

Note. Pearson product-moment correlations between variables of interest. $N = 5{,}882$, except for all correlations including social support, for which the sample size was $n = 581$. * $p < 0.05$. ** $p < 0.01$

The sample analyzed did not significantly differ from the 690 participants who were excluded due to missing data on gender, SES, or mental health problems ($p > .05$). Excluded participants were, however, slightly older (Cohen's $d_{t1} = 0.21$, $d_{t2} = 0.23$) and more likely to have a one-sided or two-sided migration background, $\chi^2_{t1}(2, N = 6{,}540) = 300.48$, $p < .001$; $\chi^2_{t2}(2, N = 6{,}570) = 303.61$, $p < .001$.

Cross-Lagged Panel Analyses

Regarding the cross-lagged panel analyses, first the fit indices of the specified models were assessed, which can be seen in Table 3. The chi-square values reached statistical significance, with $p < .001$ for all models, indicating a misfit. However, as described in the Methods section, the chi-square test almost always rejects the tested model when large sample sizes are used. The RMSEA and the SRMR were both well below the cutoff of 0.05 for all models, and the CFI was always above 0.95, all indicating a good model fit.

Table 3.

Fit Indices of the Four Models

Model	*df*	χ^2	RMSEA	SRMR	CFI	AIC	BIC
Baseline Model	14	79.62	0.030	0.009	0.967	117070.3	117230.6
Unidirectional Model 1	13	74.21	0.030	0.008	0.969	117066.4	117233.3
Unidirectional Model 2	13	78.58	0.031	0.009	0.967	117071.2	117238.2
Reciprocal Model	12	73.14	0.031	0.008	0.969	117067.2	117240.9

Note. $N = 5{,}882$. RMSEA = root mean square error of approximation; SRMR = standardized root mean square residual; CFI = comparative fit index; AIC = Akaike information criterion; BIC = Bayesian information criterion.

Model comparison. To test H2a, which postulated a better model fit of the Unidirectional Model 1 compared to the Baseline Model, a chi-square difference test was

computed, which yielded a significant result, $\Delta\chi^2(1, N = 5{,}882) = 5.40$, $p = .020$. Moreover, the SRMR of Unidirectional Model 1 was lower than that of the Baseline Model, and the CFI was higher, both indicating a better fit of the Unidirectional Model 1. Overall, H2a was supported by the results. Analogously, H3a (better model fit of the Unidirectional Model 2 compared to the Baseline Model) was also tested via a chi-square difference test, which did not reach significance, $\Delta\chi^2(1, N = 5{,}882) = 0.98$, $p = .323$. Correspondingly, there was no difference in the SRMR or the CFI between the models, and the RMSEA was even higher for Unidirectional Model 2. Taken together, the results do not support H3a. To test H4a, the model fit of the Reciprocal Model was compared to that of the Baseline Model and both unidirectional models. The Reciprocal Model showed a significantly better fit than the Baseline Model, $\Delta\chi^2(2, N = 5{,}882) = 6.37$, $p = .041$, and the Unidirectional Model 2, $\Delta\chi^2(1, N = 5{,}882) = 5.42$, $p = .020$, but not better than the Unidirectional Model 1, $\Delta\chi^2(1, N = 5{,}882) = 1.00$, $p = .318$. The RMSEA for the Reciprocal Model was higher than for the Baseline Model and the Unidirectional Model 1 and the same as for the Unidirectional Model 2. The SRMR for the Reciprocal Model was lower than for the Baseline Model and the Unidirectional Model 2 but not for the Unidirectional Model 1. The CFI showed comparable evidence. H4a was thus not supported.

Parameter estimates. Figure 2 shows the estimated standardized parameters in the Reciprocal Model. While the estimates slightly differed between the specified models, the pattern of results was the same across all models. Since the Reciprocal Model contains all paths of interest, mainly the estimates of this model are discussed.

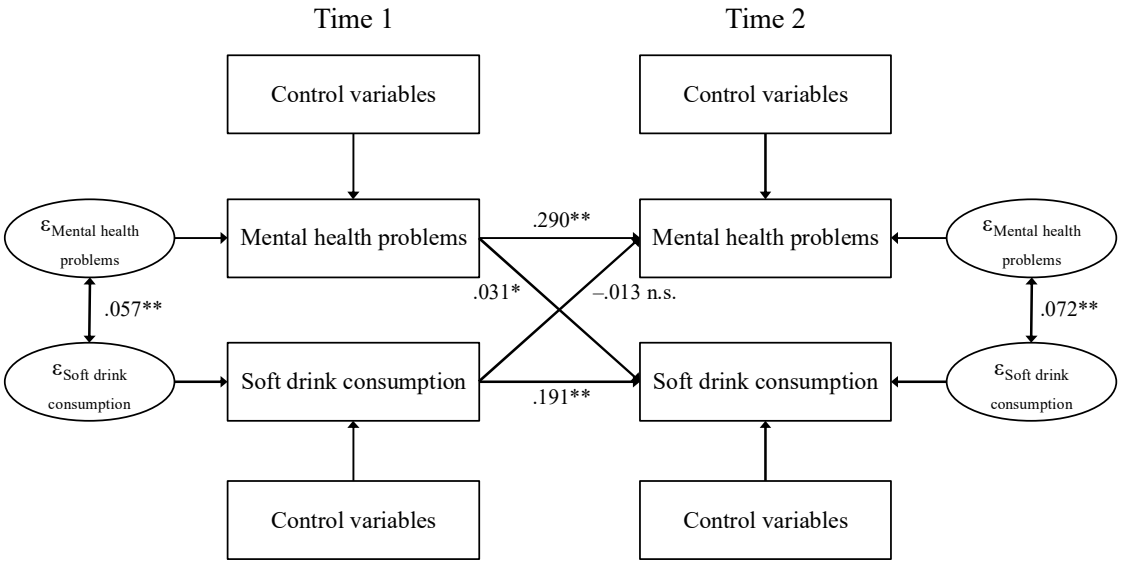

Figure 2. Estimated standardized parameters in the Reciprocal Model. Mental health problems and soft drink consumption were controlled for age, gender, migration background, and socioeconomic status at both measurement points. N = 5,882. * $p < .05$. ** $p < .01$.

The autoregressive effects of both mental health problems and soft drink consumption were positive and significant and small to medium in size. Looking at the control variables, soft drink consumption was predicted by age ($\beta_{t1} = .149$, $p < .001$; $\beta_{t2} = .139$, $p < .001$) and SES ($\beta_{t1} = –.200$, $p < .001$; $\beta_{t2} = –.124$, $p < .001$) at both measurement points. Gender ($\beta_{t1} = –.023$, $p = .061$; $\beta_{t2} = –.131$, $p < .001$) and migration background ($\beta_{t1} = –.010$, $p = .440$; $\beta_{t2} = –.034$, $p = .005$) predicted soft drink consumption only at Time 2. Mental health problems were predicted by age ($\beta_{t1} = .038$, $p = .002$; $\beta_{t2} = .028$, $p = .027$), gender ($\beta_{t1} = –.098$, $p < .001$; $\beta_{t2} = .077$, $p < .001$), and SES ($\beta_{t1} = –.212$, $p < .001$; $\beta_{t2} = –.083$, $p < .001$) at both measurement points. Migration background predicted mental health problems only at Time 1 ($\beta_{t1} = .041$, $p = .002$; $\beta_{t2} = .007$, $p = .562$).

To test H1, which assumed a positive association of mental health problems and soft drink consumption at both measurement points, the correlations of the residuals at both measurement points were tested for significance. Supporting H1, the estimates were positive

and significant at Time 1 (r_{t1} = .057, p = .001) and Time 2 (r_{t2} = .072, p < .001). As proposed in H2b and H4b, the estimated parameter for the effect of mental health problems at Time 1 on soft drink consumption at Time 2 was positive and statistically significant (β = .031, p = .020). The effect of soft drink consumption at Time 1 on mental health problems at Time 2, as postulated by H3b and H4b, did not reach statistical significance (β = –.013, p = .313). H2b was thus supported by the results, whereas H3b and H4b were not. This analysis was rerun with (a) only those n = 3,079 children and adolescents whose daily soft drink consumption was not equal to zero at either of the two measurement points, (b) the addition of dichotomous control variables that indicated if soft drink consumption and mental health problems were self- or parent reported, (c) Body Mass Index as an additional control variable, and (d) full information maximum likelihood estimation for missing data. While the estimated parameters slightly differed in size, the pattern of results was identical across all those model variants (data not shown).

Exploratory analyses. The version of the Reciprocal Model in which the scores on the four subscales of the SDQ were used separately instead of the total difficulties score also showed a good model fit, despite the significant chi-square value, $\chi^2(30, N = 5{,}882) = 116.13$, p < .001. The other fit indices all indicated a good fit (RMSEA = 0.023, SRMR = 0.007, and CFI = 0.990). At both measurement points, soft drink consumption was cross-sectionally positively and significantly associated with emotional symptoms (r_{t1} = .045, p = .005; r_{t2} = .031, p = .024), conduct problems (r_{t1} = .045, p = .004; r_{t2} = .079, p < .001), and hyperactivity (r_{t1} = .040, p = .006; r_{t2} = .059, p < .001) but not peer problems (r_{t1} = .029, p = .065; r_{t2} = .019, p = .168). Looking at the cross-lagged effects, soft drink consumption at Time 1 did not predict any of the subdimensions of the SDQ (ps > .10).

Soft drink consumption at Time 2 was significantly and positively predicted by hyperactivity at Time 1 ($\beta = .060$, $p < .001$). The other subdimensions at Time 1 did not significantly predict soft drink consumption at Time 2 (ps > .10).

The version of the Reciprocal Model that included social support at Time 1, the interaction of mental health problems and social support at Time 1, and their effects on soft drink consumption at Time 2 also showed a good overall model fit. The chi-square value did not reach statistical significance, $\chi^2(20, N = 581) = 28.80$, $p = .092$. All other fit indices met established criteria (RMSEA = 0.028, SRMR = 0.013, and CFI = 0.973). The association of soft drink consumption and the standardized interaction term between mental health problems and social support at Time 1 was negative but not significant ($r_{t1} = –.034$, $p = .467$). The same was true for the estimated parameter for the interaction's effect on soft drink consumption at Time 2 ($\beta = –.021$, $p = .609$). Thus, social support did not moderate the effect of mental health problems on soft drink consumption.

The seven multigroup analyses with different categorizations of age groups showed that the pattern of results (positive lagged effect of mental health problems on soft drink consumption, no significant lagged effect of soft drink consumption on mental health, and positive cross-sectional covariances) is generally comparable across the different age groups. Importantly, the lagged effect of mental health problems on soft drink consumption always reached statistical significance in the youngest age group, independent of how age groups were categorized ($.031 \leq \beta \leq .067$; all ps < .05). The lagged effect of mental health problems on soft drink consumption never reached significance in the oldest age group, regardless of age-group categorization variant (all ps > .05). The significant lagged effect of mental health problems on soft drink consumption thus seems to be driven largely by the youngest age group (see Table S1 in the Supplemental Materials for a summary of the multigroup analyses).

Discussion

This study investigated the directionality of the association between mental health problems and soft drink consumption in longitudinal data from a representative, nationwide survey on the health of children and adolescents in Germany. The positive cross-sectional association of mental health problems and soft drink consumption was replicated at two measurement points. The longitudinal perspective revealed a unidirectional effect of mental health problems on the consumption of soft drinks (see Figure 2). Children and adolescents might use soft drinks as an emotion-focused method of dysfunctional coping with mental health problems.

In detail, the cross-lagged panel analyses revealed that mental health problems and soft drink consumption were positively and significantly associated at both measurement points. Therefore H1 was supported by the results. This finding is in line with previous literature (e.g., Lien et al., 2006; Shi et al., 2010; Vilija and Romualdas, 2014) and extends it: The study investigated the association in a sample from Germany, where per capita soft drink consumption is comparably high (Mensink et al., 2018), and, thus, the investigation of potential predictors especially important.

In line with H2, mental health problems longitudinally predicted the consumption of soft drinks. This longitudinal effect has to date never been shown but is in line with previous speculations, which assumed soft drink consumption to be an emotion-focused method of coping for children and adolescents (Vilija and Romualdas, 2014). The result is also compatible with research on the consumption of sweet foods in response to stress (Michels et al., 2015) and negative affect (Mason et al., 2019). In contrast, neither H3 nor H4 was supported by the results. Even though there are plausible mechanisms for both directions of the association (e.g., Timonen et al., 2005; Tryon et al., 2015), this study did not find any evidence of a longitudinal effect of soft drink consumption on mental health problems or a

reciprocal effect. This finding is in line with some research (Sanchez-Villegas et al., 2018) and in contrast to other studies showing that soft drink consumption (Guo et al., 2014) and general sugar consumption (Knüppel et al., 2017) longitudinally predict depression risk. The authors, however, investigated only depression as one aspect of mental health, and they analyzed samples of adults.

In the exploratory analysis, positive cross-sectional associations of soft drink consumption with emotional symptoms, conduct problems, and hyperactivity were found. In line with previous research, soft drink consumption seems to be associated with different types of mental health problems (e.g., Lien et al., 2006; Shi et al., 2010). Soft drink consumption longitudinally did not predict any of the subdimensions. Hyperactivity at Time 1, however, did show a significant positive lagged effect on soft drink consumption at Time 2. None of the other subdimensions did. This is an interesting finding, since prior research speculated that hyperactivity might be more strongly related to soft drink consumption than other subdimensions of mental health problems (Lien et al., 2006). It has to be considered, though, that the subdimensions of mental health problems were all positively correlated, which makes the parameter estimates less precise. Furthermore, the internal consistency of some of the other subscales was low. This limits the interpretability of the results. The question of whether certain types of mental health problems, for example, hyperactivity, are more strongly associated with the consumption of soft drinks than others needs to be further researched.

No significant moderation effect of social support on the effect of mental health problems on the consumption of soft drinks was found. However, on a descriptive level, more social support was associated with a smaller effect of mental health problems on soft drink consumption, in line with the idea of social support providing coping assistance (Thoits, 1986). As previously described, the sample size for this exploratory analysis was

considerably lower than for the main analyses. Considering this and the small parameter estimates, the statistical power of the corresponding tests was substantially lower, which could partly explain the nonsignificant results. Therefore, whether social support could replace soft drinks as a coping strategy for children and adolescents cannot be conclusively answered with the current data.

The lagged effect of mental health problems on soft drink consumption consistently reached significance in the youngest age group and failed to reach significance in the oldest age group regardless of how age groups were categorized. Soft drink consumption as a coping strategy might be more relevant in younger children compared to older children and adolescents. This could partly be due to an increasing number of coping strategies that become available with age. Adolescents might, for example, turn to other substances than soft drinks to cope with their problems, such as alcohol (van der Zwaluw et al., 2011) or nicotine.

Limitations

Even though cross-lagged panel analysis is regarded as a very good method to investigate causal relations in longitudinal data, the observational nature of the data does not allow a final causal interpretation of the current findings. While it would be highly unethical to experimentally induce mental health problems, future research could manipulate indicators of mental health, such as negative affect, and test different coping responses, including soft drink consumption. Furthermore, there are important third variables that were not included in the current analyses because they were not assessed: Taste preference and the availability of soft drinks at home and school are important predictors of children's and adolescents' soft drink consumption (Grimm et al., 2004). If no soft drinks are available, coping with soft drinks is impossible. Moreover, the time lag between the two waves of the KiGGS study was on average six years. Thus, only long-term effects between mental health problems and soft drink consumption were investigated; potential short-term effects in either direction could not

be detected with the data at hand. However, that longitudinal effects of mental health problems on soft drink consumption were found given the long time lag between study waves underlines the stability of the effect. Participants excluded due to missing data differed from the analyzed sample with regard to age and migration background. Importantly, only about 10 % of participants had to be excluded, and employing full information maximum likelihood estimation for missing data did not change the pattern of results. Further, the questions assessing soft drink consumption in KiGGS Wave 1 were rather general and did not differentiate between sugar-sweetened and calorie-reduced soft drinks or between soft drinks containing or not containing caffeine. Future research should differentiate between different kinds of soft drinks to further investigate the mechanisms underlying the association found in this study. However, the broad assessment in the current study likely introduces less measurement error and makes the estimate for the association rather conservative. Additionally, at baseline, over 80% of the analyzed sample reported almost never or never consuming calorie-reduced soft drinks. Last, it should be acknowledged that the longitudinal effect found in this study was quite small. Thus, addressing mental health problems to lower the consumption of soft drinks can only be one of many intervention strategies to prevent sugar overconsumption and obesity. Importantly, a variety of different factors determine sugar consumption and obesity; there is no magic bullet but rather many small levers that need to be moved. Given that 94% of teenagers in Europe consume more sugar than recommended (Mesana et al., 2018) and that the number of children with obesity is 10 times higher than 40 years ago (Abarca-Gómez et al., 2017), every lever needs to be taken into account. Even small changes can improve population health (e.g., Reinehr et al., 2016).

Conclusions

So far, the vast majority of research has only speculated about the potential directionality of the relationship between mental health and soft drinks. Analyzing

longitudinal panel data of 5,882 children and adolescents, the current study provides initial evidence for a unidirectional effect of mental health problems on the consumption of soft drinks. Children and adolescents potentially use soft drinks as a strategy of coping with unpleasant symptoms of mental health problems. This is especially problematic considering the adverse physiological effects of soft drinks, in particular on obesity (e.g., Vartanian et al., 2007). In turn, obesity is associated with mental health problems (Mustillo et al., 2003), which might result in a vicious circle. Hence, preventing the use of soft drinks as an emotion-focused coping strategy, for example, by limiting their availability in schools and better educating the public and parents about both soft drinks and coping, is important. In addition, children and adolescents would profit from learning more adaptive ways of coping, for example, through school programs (Kraag et al., 2006). This study highlights the importance of teaching children and adolescents adaptive ways of coping with symptoms of poor mental health that might also benefit the prevention of soft drink overconsumption and, ultimately, overweight and obesity.

References

Abarca-Gómez, L., Abdeen, Z.A., Hamid, Z.A., Abu-Rmeileh, N.M., Acosta-Cazares, B., Acuin, C., et al., 2017. Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: A pooled analysis of 2416 population-based measurement studies in 128.9 million children, adolescents, and adults. The Lancet 390, 2627–2642. https://doi.org/10.1016/S0140-6736(17)32129-3

Bentler, P.M., Bonett, D.G., 1980. Significance tests and goodness of fit in the analysis of covariance structures. Psychol. Bull. 88, 588–606. https://doi.org/10.1037/0033-2909.88.3.588

Blass, E.M., Hoffmeyer, L.B., 1991. Sucrose as an analgesic for newborn infants. Pediatrics 87, 215–218. https://doi.org/10.1097/00132586-199112000-00033

Browne, M.W., Cudeck, R., 1993. Alternative ways of assessing model fit, in: Bollen, K.A., Long, J.S. (Eds.), Testing Structural Equation Models. Sage, Newbury Park, CA, pp. 136–162.

Bruckauf, Z., Walsh, S.D., 2018. Adolescents' multiple and individual risk behaviors: Examining the link with excessive sugar consumption across 26 industrialized countries. Soc. Sci. Med. 216, 133–141. https://doi.org/10.1016/j.socscimed.2018.08.029

Cheema, J.R., 2014. Some general guidelines for choosing missing data handling methods in educational research. J. Mod. Appl. Stat. Methods 13, 53–75. https://doi.org/10.22237/jmasm/1414814520

Donald, C.A., Ware, J.E., 1984. The measurement of social support. Res. Community Ment. Health 4, 325–370.

Duffey, K.J., Huybrechts, I., Mouratidou, T., Libuda, L., Kersting, M., De Vriendt, T., Gottrand, F., Widhalm, K., Dallongeville, J., Hallström, L., González-Gross, M., De

Henauw, S., Moreno, L.A., Popkin, B.M., on behalf of the HELENA Study group, 2012. Beverage consumption among European adolescents in the HELENA study. Eur. J. Clin. Nutr. 66, 244–252. https://doi.org/10.1038/ejcn.2011.166

Elkind, D., 1994. A sympathetic understanding of the child: Birth to sixteen, 3rd ed. Allyn and Bacon, Boston.

Fielding-Singh, P., Wang, J., 2017. Table talk: How mothers and adolescents across socioeconomic status discuss food. Soc. Sci. Med. 187, 49–57. https://doi.org/10.1016/j.socscimed.2017.06.016

Frank, L., Yesil-Jürgens, R., Born, S., Hoffmann, R., Santos-Hövener, C., Lampert, T., 2018. Improving the inclusion and participation of children and adolescents with a migration background in KiGGS Wave 2. J. Health Monit. 3, 126–142. https://doi.org/10.17886/rki-gbe-2018-034

Geers, A.L., Van Wasshenova, E., Murray, A.B., Mahas, R., Fahlman, M., Boardley, D., 2017. Affective associations as predictors of health behavior in urban minority youth. Health Psychol. 36, 996–1005. https://doi.org/10.1037/hea0000546

Goodman, A., Goodman, R., 2009. The Strengths and Difficulties Questionnaire as a dimensional measure of child mental health. J. Am. Acad. Child Adolesc. Psychiatry 48, 400–403. https://doi.org/10.1097/CHI.0b013e3181985068

Goodman, R., 1997. The Strengths and Difficulties Questionnaire: A research note. J. Child Psychol. Psychiatry 38, 581–586. https://doi.org/10.1111/j.1469-7610.1997.tb01545.x

Grimm, G.C., Harnack, L., Story, M., 2004. Factors associated with soft drink consumption in school-aged children. J. Am. Diet. Assoc. 104, 1244–1249. https://doi.org/10.1016/j.jada.2004.05.206

Guo, X., Park, Y., Freedman, N.D., Sinha, R., Hollenbeck, A.R., Blair, A., Chen, H., 2014. Sweetened beverages, coffee, and tea and depression risk among older US adults. PLoS ONE 9, e94715. https://doi.org/10.1371/journal.pone.0094715

Hasselkvist, A., Johansson, A., Johansson, A.-K., 2014. Association between soft drink consumption, oral health and some lifestyle factors in Swedish adolescents. Acta Odontol. Scand. 72, 1039–1046. https://doi.org/10.3109/00016357.2014.946964

Hegadoren, K.M., O'Donnell, T., Lanius, R., Coupland, N.J., Lacaze-Masmonteil, N., 2009. The role of β-endorphin in the pathophysiology of major depression. Neuropeptides 43, 341–353. https://doi.org/10.1016/j.npep.2009.06.004

Hirth, J.M., Rahman, M., Berenson, A.B., 2011. The association of posttraumatic stress disorder with fast food and soda consumption and unhealthy weight loss behaviors among young women. J. Womens Health 20, 1141–1149. https://doi.org/10.1089/jwh.2010.2675

Hölling, H., Schlack, R., Kamtsiuris, P., Butschalowsky, H., Schlaud, M., Kurth, B.M., 2012. The KiGGS study. Nationwide representative longitudinal and cross-sectional study on the health of children and adolescents within the framework of health monitoring at the Robert Koch Institute. Bundesgesundheitsblatt Gesundheitsforschung Gesundheitsschutz 55, 836–842. https://doi.org/10.1007/s00103-012-1486-3

Hu, D., Cheng, L., Jiang, W., 2019. Sugar-sweetened beverages consumption and the risk of depression: A meta-analysis of observational studies. J. Affect. Disord. 245, 348–355. https://doi.org/10.1016/j.jad.2018.11.015

Hu, L.-T., Bentler, P.M., 1995. Evaluating model fit, in: Hoyle, R.H. (Ed.), Structural Equation Modeling: Concepts, Issues, and Applications. Sage, Thousand Oaks, CA, pp. 76–99.

Kamtsiuris, P., Lange, M., Schaffrath Rosario, A., 2007. The German Health Interview and Examination Survey for Children and Adolescents (KiGGS): Sample design, response and nonresponse analysis. Bundesgesundheitsblatt Gesundheitsforschung Gesundheitsschutz 50, 547–556. https://doi.org/10.1007/s00103-007-0215-9

Kang, D., Kim, Y., Je, Y., 2018. Non-alcoholic beverage consumption and risk of depression: Epidemiological evidence from observational studies. Eur. J. Clin. Nutr. 72, 1506–1516. https://doi.org/10.1038/s41430-018-0121-2

Kearney, M.W., 2017. Cross-lagged panel analysis, in: Allen, M.R. (Ed.), The SAGE Encyclopedia of Communication Research Methods. Sage, Thousand Oaks, CA, pp. 1–6.

Klipker, K., Baumgarten, F., Göbel, K., Lampert, T., Hölling, H., 2018. Mental health problems in children and adolescents in Germany. Results of the cross-sectional KiGGS wave 2 study and trends. J. Health Monit. 3, 34–41. https://doi.org/10.17886/rki-gbe-2018-084

Knüppel, A., Shipley, M.J., Llewellyn, C.H., Brunner, E.J., 2017. Sugar intake from sweet food and beverages, common mental disorder and depression: prospective findings from the Whitehall II study. Sci. Rep. 7. https://doi.org/10.1038/s41598-017-05649-7

Koekkoek, L.L., Mul, J.D., la Fleur, S.E., 2017. Glucose-sensing in the reward system. Front. Neurosci. 11, 716. https://doi.org/10.3389/fnins.2017.00716

Kraag, G., Zeegers, M.P., Kok, G., Hosman, C., Abu-Saad, H.H., 2006. School programs targeting stress management in children and adolescents: A meta-analysis. J. Sch. Psychol. 44, 449–472. https://doi.org/10.1016/j.jsp.2006.07.001

Kuiper, R.M., Ryan, O., 2018. Drawing conclusions from cross-lagged relationships: Re-considering the role of the time-interval. Struct. Equ. Model. Multidiscip. J. 25, 809–823. https://doi.org/10.1080/10705511.2018.1431046

Lampert, T., Müters, S., Stolzenberg, H., Kroll, L.E., the KiGGS Study Group, 2014. Measurement of socioeconomic status in the KiGGS study. First follow-up (KiGGS Wave 1). Bundesgesundheitsblatt Gesundheitsforschung Gesundheitsschutz 57, 762–770. https://doi.org/10.1007/s00103-014-1974-8

Lange, M., Butschalowsky, H.G., Jentsch, F., Kuhnert, R., Schaffrath Rosario, A., Schlaud, M., Kamtsiuris, P., 2014. The first KiGGS follow-up (KiGGS Wave 1). Study conduct, sample design, and response. Bundesgesundheitsblatt Gesundheitsforschung Gesundheitsschutz 57, 747–761. https://doi.org/10.1007/s00103-014-1973-9

Lien, L., Lien, N., Heyerdahl, S., Thoresen, M., Bjertness, E., 2006. Consumption of soft drinks and hyperactivity, mental distress, and conduct problems among adolescents in Oslo, Norway. Am. J. Public Health 96, 1815–1820. https://doi.org/10.2105/AJPH.2004.059477

Mason, T.B., O'Connor, S.G., Schembre, S.M., Huh, J., Chu, D., Dunton, G.F., 2019. Momentary affect, stress coping, and food intake in mother–child dyads. Health Psychol. 38, 238–247. https://doi.org/10.1037/hea0000714

Mensink, G.B., Schienkiewitz, A., Rabenberg, M., Borrmann, A., Richter, A., Haftenberger, M., 2018. Consumption of sugary soft drinks among children and adolescents in Germany. Results of the cross-sectional KiGGS Wave 2 study and trends. J. Health Monit. 3, 32–39. https://doi.org/10.17886/rki-gbe-2018-007

Mesana, M.I., Hilbig, A., Androutsos, O., Cuenca-García, M., Dallongeville, J., Huybrechts, I., De Henauw, S., Widhalm, K., Kafatos, A., Nova, E., Marcos, A., González-Gross, M., Molnar, D., Gottrand, F., Moreno, L.A., 2018. Dietary sources of sugars in adolescents' diet: The HELENA study. Eur. J. Nutr. 57, 629–641. https://doi.org/10.1007/s00394-016-1349-z

Michels, N., Sioen, I., Boone, L., Braet, C., Vanaelst, B., Huybrechts, I., De Henauw, S., 2015. Longitudinal association between child stress and lifestyle. Health Psychol. 34, 40–50. https://doi.org/10.1037/hea0000108

Mustillo, S., Worthman, C., Erkanli, A., Keeler, G., Angold, A., Costello, E.J., 2003. Obesity and psychiatric disorder: Developmental trajectories. Pediatrics 111, 851–859. https://doi.org/10.1542/peds.111.4.851

Palanker Musselman, L., Fink, J.L., Narzinski, K., Ramachandran, P.V., Sukumar Hathiramani, S., Cagan, R.L., Baranski, T.J., 2011. A high-sugar diet produces obesity and insulin resistance in wild-type Drosophila. Dis. Model. Mech. 4, 842–849. https://doi.org/10.1242/dmm.007948

Park, S., Blanck, H.M., Sherry, B., Foti, K., 2013. Problem behavior, victimization, and soda intake in high school students. Am. J. Health Behav. 37, 414–421. https://doi.org/10.5993/AJHB.37.3.14

Piontak, J.R., Russell, M.A., Danese, A., Copeland, W.E., Hoyle, R.H., Odgers, C.L., 2017. Violence exposure and adolescents' same-day obesogenic behaviors: New findings and a replication. Soc. Sci. Med. 189, 145–151. https://doi.org/10.1016/j.socscimed.2017.07.004

Reinehr, T., Lass, N., Toschke, C., Rothermel, J., Lanzinger, S., Holl, R.W., 2016. Which amount of BMI-SDS reduction is necessary to improve cardiovascular risk factors in overweight children? J. Clin. Endocrinol. Metab. 101, 3171–3179. https://doi.org/10.1210/jc.2016-1885

Reiss, F., 2013. Socioeconomic inequalities and mental health problems in children and adolescents: A systematic review. Soc. Sci. Med. 90, 24–31. https://doi.org/10.1016/j.socscimed.2013.04.026

Rosseel, Y., 2012. Lavaan: An R package for structural equation modeling and more. J. Stat. Softw. 48, 1–36.

Sanchez-Villegas, A., Zazpe, I., Santiago, S., Perez-Cornago, A., Martinez-Gonzalez, M.A., Lahortiga-Ramos, F., 2018. Added sugars and sugar-sweetened beverage consumption, dietary carbohydrate index and depression risk in the Seguimiento Universidad de Navarra (SUN) Project. Br. J. Nutr. 119, 211–221. https://doi.org/10.1017/S0007114517003361

Satorra, A., Bentler, P.M., 1994. Corrections to test statistics and standard errors in covariance structure analysis, in: von Eye, A., Clogg, C.C. (Eds.), Latent Variables Analysis: Applications for Developmental Research. Sage, Thousand Oaks, CA, pp. 399–419.

Shi, Z., Taylor, A.W., Wittert, G., Goldney, R., Gill, T.K., 2010. Soft drink consumption and mental health problems among adults in Australia. Public Health Nutr. 13, 1073–1079. https://doi.org/10.1017/S1368980009993132

Stein, E.R., Smith, B.W., 2015. Social support attenuates the harmful effects of stress in healthy adult women. Soc. Sci. Med. 146, 129–136. https://doi.org/10.1016/j.socscimed.2015.10.038

Steptoe, A., 2000. Stress, social support and cardiovascular activity over the working day. Int. J. Psychophysiol. 37, 299–308. https://doi.org/10.1016/S0167-8760(00)00109-4

Suglia, S.F., Solnick, S., Hemenway, D., 2013. Soft drinks consumption is associated with behavior problems in 5-year-olds. J. Pediatr. 163, 1323–1328. https://doi.org/10.1016/j.jpeds.2013.06.023

Thoits, P.A., 1986. Social support as coping assistance. J. Consult. Clin. Psychol. 54, 416–423.

Timonen, M., Laakso, M., Jokelainen, J., Rajala, U., Meyer-Rochow, V.B., Keinänen-Kiukaanniemi, S., 2005. Insulin resistance and depression: Cross sectional study. Br. Med. J. 330, 17–18. https://doi.org/10.1136/bmj.38313.513310.F71

Tryon, M.S., Stanhope, K.L., Epel, E.S., Mason, A.E., Brown, R., Medici, V., Havel, P.J., Laugero, K.D., 2015. Excessive sugar consumption may be a difficult habit to break: A view from the brain and body. J. Clin. Endocrinol. Metab. 100, 2239–2247. https://doi.org/10.1210/jc.2014-4353

Ulrich-Lai, Y.M., 2016. Self-medication with sucrose. Curr. Opin. Behav. Sci. 9, 78–83. https://doi.org/10.1016/j.cobeha.2016.02.015

van der Zwaluw, C.S., Kuntsche, E., Engels, R.C.M.E., 2011. Risky alcohol use in adolescence: The role of genetics (DRD2, SLC6A4) and coping motives. Alcohol. Clin. Exp. Res. 35, 756–764. https://doi.org/10.1111/j.1530-0277.2010.01393.x

Vartanian, L.R., Schwartz, M.B., Brownell, K.D., 2007. Effects of soft drink consumption on nutrition and health: A systematic review and meta-analysis. Am. J. Public Health 97, 667–675. https://doi.org/10.2105/AJPH.2005.083782

Vilija, M., Romualdas, M., 2014. Unhealthy food in relation to posttraumatic stress symptoms among adolescents. Appetite 74, 86–91. https://doi.org/10.1016/j.appet.2013.12.002

Westover, A.N., Marangell, L.B., 2002. A cross-national relationship between sugar consumption and major depression? Depress. Anxiety 16, 118–120. https://doi.org/10.1002/da.10054

Yamamoto, T., Sako, N., Maeda, S., 2000. Effects of taste stimulation on β-endorphin levels in rat cerebrospinal fluid and plasma. Physiol. Behav. 69, 345–350. https://doi.org/10.1016/S0031-9384(99)00252-8