

# At-Home Environment, Out-of-Home Environment, Snacks and Sweetened Beverages Intake in Preadolescence, Early and Mid-Adolescence: The Interplay Between Environment and Self-Regulation

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**Abstract** Obesity-related behaviors, such as intake of snacks and sweetened beverages (SSB), are assumed to result from the interplay between environmental factors and adolescents' ability to self-regulate their eating behaviors. The empirical evidence supporting this assumption is missing. This study investigated the relationships between perceptions of at-home and out-of-home food environment (including SSB accessibility, parental, and peers' social pressure to reduce intake of SSB), nutrition self-regulatory strategies (controlling temptations and suppression), and SSB intake. In particular, we hypothesized that these associations would differ across the stages of preadolescence,

early and mid-adolescence. Self-reported data were collected from 2,764 adolescents (10–17 years old; 49 % girls) from 24 schools in the Netherlands, Poland, Portugal, and the United Kingdom. Path analysis indicated that direct associations between peers' social influence and SSB intake increased with age. Direct negative associations between at-home and out-of-home accessibility and SSB intake as well as direct positive associations between parental pressure and intake become significantly weaker with age. Accessibility was related negatively to self-regulation, whereas higher social pressure was associated with higher self-regulation. The effects of the environmental factors were mediated by self-regulation. Quantitative and qualitative differences in self-regulation were observed across the stages of adolescence. The associations between the use of self-regulatory strategies and lower SSB intake become significantly stronger with age. In preadolescence, SSB intake was regulated by means of strategies that aimed at direct actions toward tempting food. In contrast, early and mid-adolescents controlled their SSB intake by means of a combination of self-regulatory strategies focusing on direct actions toward tempting food and strategies focusing on changing the psychological meaning of tempting food.

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## Introduction

Adolescence is a period of rapid changes in body composition (Daniels et al. 2005), with unfavorable body weight changes being associated with the consumption of energy-dense snacks, such as sweets, processed salty foods, and sweetened soft drinks (Piernas and Popkin 2010). Changes

in body composition and energy-dense snack intake coincide with a transition from the direct influence of at-home environment on nutritional behavior in preadolescence to stronger effects of the peers and out-of-home environment in mid-adolescence (Von Post-Skagegard et al. 2002; Wouters et al. 2010). Relational developmental system theories highlight the role of the environmental factors in adolescent development (Bronfenbrenner and Morris 2006). Unfortunately, the evidence for the complex interplay between at-home and out-of-home environment in predicting the consumption of energy-dense snacks is missing.

The acquisition of intentional self-regulation is a fundamental facet of development in adolescence (Gestsdottir et al. 2011). Intentional self-regulation involves applying strategies directed at attaining goals and seeking resources that allow pursuing goals. It allows individuals to exercise control over the environment (Bandura 1997; Gestsdottir et al. 2011). Self-regulation may include processes of selection, compensation, and optimization (Gestsdottir et al. 2010). While selection and compensation strategies refer to choosing and reconstructing one's own goals, optimization processes focus on choosing strategies that represent the best fit for the social, cultural, and environmental context. Accounting for the cross-cultural perspective, the present study investigates the roles of optimization strategies across three developmental stages of adolescence.

Self-regulation becomes more complex and evolves from early to mid-adolescence (Gestsdottir et al. 2010). Longitudinal research has shown that higher levels of self-regulatory skills, such as the general ability to control impulses and delay gratification promote healthier weight-related behaviors and healthy body weight in mid-adolescence (Tsukayama et al. 2010). A growing body of evidence highlights the role of general self-regulatory strategies for thriving and health in adolescence (Gestsdottir et al. 2010, 2011). Unfortunately, little is known about the role of nutrition-specific self-regulation, helping adolescents to regulate food intake.

Theories explaining health behaviors, such as Social Cognitive Theory (Bandura 1997), propose that self-regulatory cognitions operate in concert with perceptions of the environment. Recent theoretical developments, such as the Environmental Research Framework for Weight Gain Prevention (EnRG; Kremers et al. 2006), suggested that environmental variables are associated directly with nutrition behaviors. Additionally, environmental variables operate indirectly, by promoting or hindering cognitive self-regulation (Kremers et al. 2006). The present study investigates the interplay between the environmental variables and nutrition self-regulation in the context of snack and sweetened

beverages (SSB) intake at different stages of development: preadolescence (age: 10–11 years), early adolescence (age: 12–14 years), and mid-adolescence (age: 15–17 years). In particular, we tested if the environment–SSB intake relationships would change from direct in earlier stages to indirect effects in mid-adolescence, with nutrition self-regulation playing the mediating role.

#### At-Home Environment, Self-Regulation, Snack and Sweetened Beverage Intake

It is often hypothesized that the role of at-home environment may decline across adolescence while the exposure to obesogenic out-of-home environment increases from childhood to mid-adolescence (Steinberg and Morris 2001; Wouters et al. 2010). Adolescence is characterized by an increase of leisure time spent with peers in structured or unstructured out-of-home activities (Larson and Verma 1999). Parental social influence, such as active discouragement or disapproval of a behavior (Graham et al. 1991), may become progressively less important in later stages of adolescence (Harris 1995).

Research analyzing the associations between at-home environment and SSB intake in adolescence offers diverse conclusions. For example, Campbell et al. (2007) indicated that at-home accessibility directly predicts SSB intake in early adolescence, whereas Martens et al. (2010) found no significant associations. This discrepancy may result from changes in the character of the associations between the at-home environment and adolescents' behaviors. It has been suggested that the influence of parents and at-home environment does not disappear across adolescence, but rather is transformed (Steinberg and Morris 2001). Although parental actions directly influence behaviors of preadolescents, in later stages of adolescence parental behaviors have little direct effect but they support agency and thriving for behavioral autonomy (Allen 2010; Steinberg and Morris 2001). Thus, the at-home environment shapes mid-adolescents' behavior in an indirect manner, affecting young people's self-regulation.

#### Out-of-Home Environment, Self-Regulation, Snack and Sweetened Beverage Intake

Peers' social influence and the out-of-home environment have been thought to be important determinants of adolescents' behavior (Steinberg and Morris 2001). The direct associations between out-of-home availability of snacks and unhealthy food habits were found among early adolescents (Cullen et al. 2000). On the other hand, systematic reviews suggest that direct associations between peers'

influence and SSB intake are weak (de Vet et al. 2011; Safron et al. 2011). This may be explained by the fact that out-of-home factors start to operate in an indirect manner, as self-regulatory capacity evolves across later stages of adolescence.

The presence of direct and indirect associations mediated by self-regulation between out-of-home environmental variables and SSB intake would be in line with the EnRG model (Kremers et al. 2006) and Social Cognitive Theory (Bandura 1997). Hence, low out-of-home accessibility to SSB and higher peer pressure to reduce intake also may be associated with lower intake (the direct association). Lower accessibility and higher pressure may be related to higher self-regulation, which in turn would reduce SSB intake (the indirect association). Previous research has demonstrated that food accessibility may predict adolescents’ self-regulatory beliefs (Szczepanska et al. in press). Higher levels of self-regulatory beliefs are, in turn, related directly to healthier nutrition (Szczepanska et al. in press). In sum, out-of-home environmental factors may predict SSB intake directly and indirectly, with nutrition self-regulation playing the mediating role.

**Aims of the Study**

This study tested the direct and indirect associations between the home environment (at-home SSB accessibility, parental social influence) and out-of-home environment (out-of-home SSB accessibility, peers’ social influence) in predicting SSB intake in the context of stages of

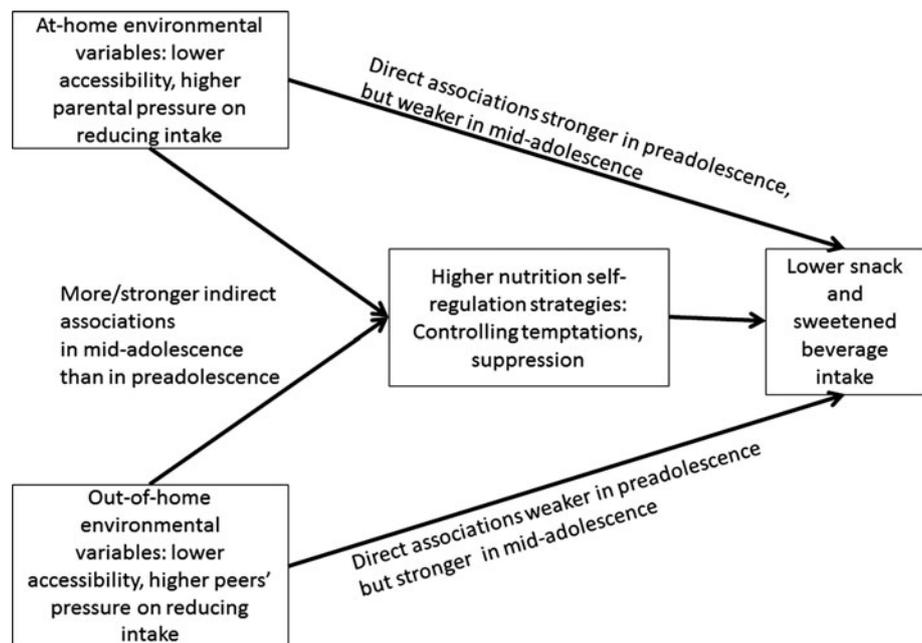
adolescence. Self-regulatory strategies aiming at changing the psychological meaning of food temptations (suppression strategy) and direct actions towards food temptations (controlling temptation strategy) were investigated. In line with previous research (de Vet et al. 2011; Safron et al. 2011), we hypothesized that higher self-regulation, higher parental and peer pressure on reducing intake would be related to lower consumption of SSB, whereas higher SSB accessibility would be associated with higher intake. In particular, we hypothesized that the *direct* associations between at-home environmental variables and SSB beverage intake would become weaker across adolescence, whereas the *direct* associations between out-of-home environment and SSB intake would become stronger across adolescence. Further, it was hypothesized that the at-home and out-of-home environment variables would be related *indirectly* (with self-regulation as the mediator) with SSB intake across adolescence, with these indirect pathways being stronger in the older adolescents. Figure 1 displays a simplified hypothetical model, representing direct and indirect associations across age groups.

**Method**

**Participants and Procedures**

A total of 2764 adolescents (51 % boys) provided their data. Mean age was 13.2 years (*SD* = 1.9). 22.4 % (*n* = 620) were 10–11 years old, 51.3 % (*n* = 1418) were 12–14 years old, and 26.3 % (*n* = 725) were 15–17 years old. Across adolescence, the majority of participants

**Fig. 1** The hypothetical associations between the study variables



reported normal body weight (10-years-olds: 77 %, 11-years-olds: 89 %, 12-years-olds: 80 %, 13-years-olds: 81 %, 14-years-olds: 88 %, 15-years-olds: 84 %, 16-years-olds: 82 %; 17-years-olds: 86 %) according to WHO cut-off scores (De Onis et al. 2007).

Data were collected at 24 schools in four countries as part of the European Union TEMPEST project. The countries involved were: the Netherlands ( $n = 586$ ), Poland ( $n = 832$ ), Portugal ( $n = 517$ ), and the United Kingdom ( $n = 829$ ). Participants were drawn from urban (49.1 %) or rural (50.9 %) communities and represented higher (68.6 %) or lower (31.4 %) socio-economic status. Researchers visited the schools to administer the questionnaires in a single session, lasting 30–45 min. Similar procedures were used across the four countries. The researchers were present during data collection to respond to questions. Questionnaire items included in this analysis measured sociodemographic variables, body weight and height, SSB intake, environmental variables, and the use of self-regulation strategies. The questionnaires were developed in English. Dutch, Portuguese, and Polish versions were developed using back-translation from the English language version. Data collection methods followed the ethical guidelines relevant to each country, with approval from the relevant Institutional Review Boards. Participants' and parental active or passive consents were obtained, depending on the IRB guidelines in the respective countries.

## Measures

### *Snacks and Sweetened Beverage Intake*

SSB consumption was measured with two items “How many glasses of soft drinks, lemonade or energy drinks do you drink on an average day” and “How many snacks do you eat on an average day (followed by examples of country-specific snacks).” The items were based on previous measures of daily SSB intake (Lally et al. 2011). The response scale varied from less than 1/none (scored 0) to more than 4 (scored 5). The items were correlated,  $r = .30$ ,  $p < .001$ .

### *Nutrition Self-Regulation*

Self-regulation strategies were assessed with two subscales of the TESQ-E (De Vet et al. submitted). This questionnaire proposes six types of strategies, aiming at food intake regulation in adolescence. Strategies representing self-regulatory optimization processes (Gestsdottir et al. 2010) were used in the present study. Controlling temptations was assessed with four items (e.g. “If I want to have a treat, I

take a little bit and put the rest out of sight”), with Cronbach's alpha of .73. Suppression was measured with four items (e.g. “If I pass a bakery, I ignore the smells of tasty foods”), with Cronbach's alpha of .79. Responses were on a scale ranging from 1 (never) to 5 (always).

### *Perceived At-Home Environment*

Two variables, parental influence on SSB intake and perceived at-home accessibility of SSB were assessed. Parental social influence on reducing SSB intake was evaluated with two items, “My parents discourage me from eating snacks or drinking fizzy drinks” and “My parents disapprove of my eating snacks or drinking fizzy drinks”. The items were based on previous measures of active social influence (Graham et al. 1991). The response scale ranged from 1 (strongly disagree) to 5 (strongly agree). The items were correlated,  $r = .44$ ,  $p < .001$ . At-home SSB accessibility was measured with two items, “Are you allowed to help yourself to snacks in your home (like crisps, peanuts, cookies, or chocolate bars)” and “Are you allowed to help yourself to fizzy drinks, lemonade or energy drinks in your home (don't count light drinks such as diet coke or mineral water)”, derived from food accessibility measure by Bryant et al. (2008). Response scale ranged from 1 (never) to 5 (always), with an additional response option “we never have snacks/fizzy drinks, lemonade or energy drinks at home” (coded as 1). The items were correlated,  $r = .54$ ,  $p < .001$ .

### *Perceived Out-of-Home Environment*

Two variables, peer influence on SSB intake and perceived out-of-home accessibility of SSB were evaluated. Peer social influence on reducing SSB intake was assessed with two items, “My friends discourage me from eating snacks or drinking fizzy drinks, lemonade or energy drinks” and “My friends disapprove of my eating snacks or drinking fizzy drinks”, based on measures of active social influence (Graham et al. 1991). The response scale ranged from 1 (strongly disagree) to 5 (strongly agree). The items were correlated,  $r = .52$ ,  $p < .001$ . Out-of-home SSB accessibility was assessed with two items, based on items measuring accessibility developed by Bryant et al. (2008), “Whenever I feel like having a snack or soft drink during school breaks, I can easily get it (like from a vending machine, canteen or shop)” and “Whenever I feel like having a snack or soft drink when I hang out with my friends, I can easily get it (like from a vending machine, shop or fast food outlet)”. Responses were given on 5-point scale from 1 (strongly disagree) to 5 (strongly agree). The items were correlated,  $r = .56$ ,  $p < .001$ .

Data Analysis

Missing data were imputed using the expectation maximization algorithm for SPSS (Enders 2001). Data were analyzed using SPSS version 20 and AMOS 20 for path analyses (IBM Corporation, Chicago, IL). The hypothesized path model included 6 observed predictor variables, representing mean item responses, and two observed control variables (country and gender). Two self-regulation strategies were specified as predictors of SSB intake. Parental social influence and peers' social influence were specified as predictors of two self-regulation strategies and SSB. At-home and out-of-home accessibility were specified as predictors of two self-regulation variables and SSB intake (Fig. 1). Two control variables, gender (male = 1, female = 2) and country (1 = NL, 0 = other; the Netherlands differed significantly in SSB from Poland, Portugal and UK, whereas participants in Poland, Portugal and UK reported similar SSB intake), were also included in the model. The exogenous variables (including control variables) were assumed to be associated (Byrne 2009). Mediators' disturbances were allowed to covary.

The analyses were conducted for a three-group model, with preadolescents (10–11), early adolescents (12–14) and mid-adolescents (15–17) analyzed as the three groups. Evaluation of model-data fit was based on Tucker-Lewis Index (TLI), Comparative Fit Index (CFI), Normed Fit Index (NFI), Root Mean Square Error of Approximation (RMSEA), Standardized Root Mean Residual (SRMR), and  $\chi^2/df$ . The following values indicate an acceptable fit: TLI, CFI, values above .90, SRMR and RMSEA values of .05 or less (Byrne 2009). Across study variables there was no deviation from normality (multivariate non-normality Mardia index of 1.80). Following the suggestions by Kenny et al. (1998), we assumed two essential steps in establishing mediation: (1) the independent variable should be related to the mediator and (2) the mediator should be associated with the outcome variable when controlling for the independent variable. Sobel Z test was used to test if the hypothesized mediation was significant.

Results

Preliminary Analysis

More than half of participants (58.9 %) agreed or strongly agreed that they could easily access SSB in their out-of-home environment, and 60.3 % agreed or strongly agreed that SSB are accessible to them at home. Correlations between study variables are displayed in Table 1. Boys reported higher SSB intake ( $M = 2.09, SD = 1.21$ ) than girls ( $M = 1.83; SD = 1.17$ ),  $F(1, 2760) = 32.18, p < .001$ . Older age was related to higher SSB intake,  $r = .06, p = .002$ . Analysis of variance showed significant between-country differences in SSB intake,  $F(3, 2760) = 8.88, p < .001$ , with post hoc tests indicating higher snacks intake in the Netherlands ( $M = 2.18, SD = 1.13$ ) compared to the three remaining countries (Portugal:  $M = 1.93, SD = 1.25$ ; Poland:  $M = 1.91, SD = 1.27$ ; UK:  $M = 1.87, SD = 1.12$ ).

Analyses indicated that models assuming equality of weights, intercepts, means, covariances, and residuals across three age groups yielded similar fit (RMSEA from .02 to .06). Thus, the overall differences in means and covariances which could be observed across the three age groups may be considered marginal and irrelevant for the tested associations.

Modeling Direct and Indirect Associations Between Environmental Variables and Snacks/Sweetened Beverages Intake

Path analysis was conducted for the three-group model. The hypothesized model fit the data well, with  $\chi^2(21) = 54.93, p < .001, CFI = .99, TLI = .93, NFI = 0.98, SRMR = .01, RMSEA = .02$  (90 % CI = 0.02–0.03). The standardized solution with path coefficients for the three age groups is presented in Fig. 2. In general, higher self-regulation and higher parental and peer pressure on reducing intake was related to lower SSB intake. Higher at-home and out-of-home accessibility of SSB was associated with higher SSB intake and related to lower nutrition self-regulation.

**Table 1** Correlations and descriptive statistics for the study variables ( $N = 2,764$  adolescents)

	<i>M (SD)</i>	2	3	4	5	6	7	8
1 Snacks/sweetened beverages (SSB) intake	1.96 (1.96)	.34***	.21***	-.15***	-.07***	-.24***	.22***	.06**
2 At-home accessibility of SSB	3.51 (1.15)		.29***	-.22***	-.11***	-.32***	-.23***	.31***
3 Out-of-home accessibility of SSB	3.44 (1.10)			-.06**	-.06**	-.20***	-.14***	.32***
4 Parental social influence	3.18 (0.97)				.46***	.24***	.26***	-.12***
5 Peers' social influence	2.56 (1.00)					.21***	.26***	-.09***
6 Controlling temptations (self-regulation strategy)	2.41 (0.96)						.55***	-.27***
7 Suppression (self-regulation strategy)	2.15 (0.94)							-.20***
8 Age	13.17 (1.92)							

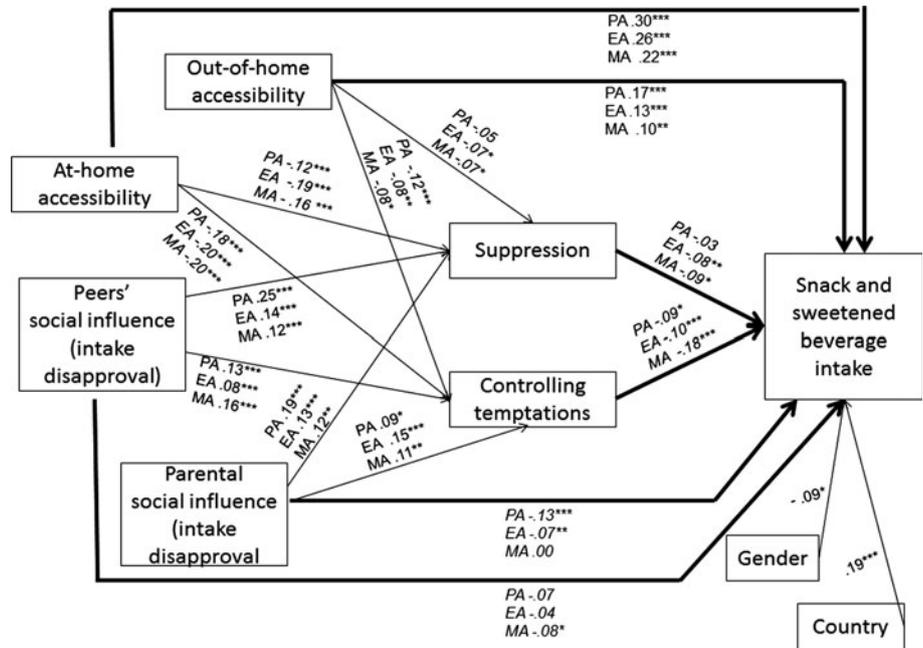
\*\*  $p < .01$ , \*\*\*  $p < .001$

*Preadolescents*

Among preadolescents a higher level of controlling temptation, higher parental social influence, and lower at-home and out-of-home accessibility were associated directly with lower SSB intake (Fig. 2). The controlling temptations strategy mediated between the environmental predictors and SSB intake (Table 2). In particular, lower accessibility and higher parental social pressure on reducing intake were associated with more frequent use of controlling tempta-

tions, which in turn was related to lower SSB intake. As the relationship between suppression and SSB intake was non-significant, no mediating effects were established for this variable. Standardized indirect effects of predictors on the outcome ranged from .04 for at-home accessibility to .01–.02 for other environmental variables. Standardized direct effects of environmental variables on self-regulation varied from .09 to .14 for at-home environment and from .04 to .25 for out-of-home environment. The variables included in the model explained 20 % of variance of SSB intake.

**Fig. 2** The associations between perceived at-home and out-of-home environments, self-regulation, and consumption of snack and soft drinks: Results of the path analysis, the three-group model (preadolescents, early adolescents, and mid-adolescents). *PA* preadolescents, *EA* early adolescents, *MA* mid-adolescents; \**p* < .05, \*\**p* < .01, \*\*\**p* < .001; **bold lines** represent the associations which are significantly different across the three age groups; negative associations are displayed in *italics*; gender: male = 1, female = 2; country: the Netherlands = 1, other = 0



**Table 2** Results of mediation analysis in preadolescents (*n* = 620), early adolescents (*n* = 1418) and mid-adolescents (*n* = 725)

Variables and mediating relationships: Independent variable → Mediator → Dependent variable	Sobel Z test		
	Preadolescence	Early adolescence	Mid-adolescence
Lower at-home accessibility → Higher controlling temptations → Lower SSB intake	2.12 ( <i>p</i> = 0.034)	3.06 ( <i>p</i> = 0.001)	3.44 ( <i>p</i> = 0.001)
Higher parental social influence (intake discouragement) → Higher controlling temptations → Lower SSB intake	2.49 ( <i>p</i> = 0.013)	2.72 ( <i>p</i> = 0.003)	2.17 ( <i>p</i> = 0.040)
Lower out-of-home accessibility → Higher controlling temptations → Lower SSB intake	1.97 ( <i>p</i> = 0.049)	2.38 ( <i>p</i> = 0.017)	2.05 ( <i>p</i> = 0.040)
Higher peers' social influence (intake discouragement) → Higher controlling temptations → Lower SSB intake	1.97 ( <i>p</i> = 0.049)	2.06 ( <i>p</i> = 0.039)	2.84 ( <i>p</i> = 0.005)
Lower at-home accessibility → Higher suppression → Lower SSB intake	d.n.a	2.60 ( <i>p</i> = 0.009)	1.98 ( <i>p</i> = 0.048)
Higher parental social influence (intake discouragement) → Higher suppression → Lower SSB intake	d.n.a	2.50 ( <i>p</i> = 0.012)	2.01 ( <i>p</i> = 0.045)
Lower out-of-home accessibility → Higher suppression → Lower SSB intake	d.n.a	2.03 ( <i>p</i> = 0.043)	1.94 ( <i>p</i> = 0.053)
Higher peers' social influence (intake discouragement) → Higher suppression → Lower SSB intake	d.n.a	2.32 ( <i>p</i> = 0.020)	2.68 ( <i>p</i> = 0.007)

d.n.a does not apply due to a lack of significant relationships between the mediator and the independent variables

### Early Adolescents

In early adolescence, a higher level of the two self-regulation strategies (controlling temptations and suppression), higher parental social influence, and lower at-home and out-of-home accessibility were associated with lower SSB intake (Fig. 2). Strategies of controlling temptations and suppression mediated the relationships between the environmental variables and SSB intake (Table 2). Standardized indirect effects of predictors on outcome were small (at-home accessibility: .05; parental social influence: .03; peer's influence: .02; out-of-home accessibility: .01). Standardized direct effects of environmental variables on self-regulation varied from .13 to .23 for at-home environment and from .08 to .14 for out-of-home environment. The variables included in the model explained 19 % of variance of SSB intake.

### Mid-Adolescents

Finally, in mid-adolescence a higher level of two self-regulation strategies (controlling temptations and suppression), higher peers' influence, and lower at-home and out-of-home accessibility were associated directly with lower SSB intake (Fig. 2). As in younger age groups, controlling temptations mediated the relationships between the environmental variables and SSB intake. As in early adolescence, suppression mediated between the environmental variables and SSB intake (Table 2). Standardized indirect effects were small (home accessibility: .05; parental social influence: .03; peer's influence: .04; out-of-home accessibility: .02). Standardized direct effects of environmental variables on self-regulation varied from .11 to .22 for at-home environment and from .08 to .16 for out-of-home environment. The predictors explained a total of 17 % of variance of SSB intake.

### Age as a Moderator of Associations Between the Environment, Self-Regulation and SSB Intake

To further test if the strength of the analyzed associations differs significantly across the three age groups, we evaluated *five nested models*. The first nested model assumed a lack of significant differences in direct associations between self-regulation and SSB intake across the three age groups. The results indicated that these associations differ significantly in the three stages of adolescence,  $\Delta\chi^2(4) = 9.28, p = .05$ . The second model assumed the direct associations between out-of-home environment (accessibility and peers' social influence) and SSB intake are similar across age groups. The comparison analysis indicated that this model should be rejected as well,  $\Delta\chi^2(4) = 35.45,$

$p = .00$ . Thus, the relationships between out-of-home environment and SSB intake differ significantly in the three stages of adolescence. The third model assumed that direct associations between at-home environment and SSB intake are equal across age groups. This model should be rejected as well,  $\Delta\chi^2(4) = 10.34, p = .04$ . Therefore, the associations between out-of-home environment and SSB intake differ significantly in the three stages of adolescence.

Further analyses tested the between-groups differences in associations between environment variables and self-regulation. The model assuming equal paths from at-home environment to self-regulation ( $\Delta\chi^2(8) = 8.15, p = .42$ ) and the model assuming equal paths from out-of-home environment to self-regulation ( $\Delta\chi^2(8) = 10.22, p = .25$ ) should be accepted. In sum environment—self-regulation associations are equal across the age groups.

Concluding, nested model analyses indicated that all direct relationships between the analyzed predictors (self-regulation, at-home environment, and out-of-home environment) and SSB intake differ significantly (in terms of their strength) across the stages of adolescence. An inspection of the path coefficients (Fig. 2) indicates that the strength of direct relationships between at-home variables and out-of-home accessibility and SSB intake was decreasing from preadolescence to mid-adolescence. By contrast, associations between peer pressure and SSB intake as well as the direct relationships between self-regulation and SSB intake become significantly stronger across adolescence.

### Discussion

Although there is considerable evidence for the role of general self-regulation (Gestsdottir et al. 2010, 2011), at-home environmental factors (Campbell et al. 2007), and out-of-home environment (Van Ryzin 2011) in predicting adolescents' behaviors and well-being, the complex relations between these three groups of variables have been investigated rarely. To date, research on the interplay of the self-regulation and environmental factors in adolescence has focused on either the at-home environment (Williams et al. 2012) or out-of-home environment (Van Ryzin 2011). Studies accounting for social influence and accessibility at both at-home and out-of-home environments have been missing. Further, the associations between self-regulation strategies and unhealthy eating across stages of adolescence remain unknown: Few studies, which addressed this topic, overlooked the differences between the stages of adolescence (Kalavana et al. 2010). The present research fills this void and offers an insight into the changes in the environment—self-regulation—eating associations across three stages of adolescence. Data collected among young

people from four countries suggested that the analyzed relationships evolve from direct associations between at-home environment and SSB intake in preadolescence, to associations mediated by self-regulation in mid-adolescence. The effects of out-of-home environment also change across the three stages of adolescence. In particular, the strength of direct associations between out-of-home accessibility and SSB intake is decreasing from preadolescence to mid-adolescence, whereas the strength of direct associations between peers' pressure and SBB intake is increasing from early adolescence to mid adolescence. Finally, the effects of self-regulation strategies are significantly weaker in preadolescence compared to later developmental stages.

Recent research on self-regulation in adolescence was focused on the role of general self-regulatory strategies (Gestsdottir et al. 2010, 2011). The effects of nutrition-specific self-regulation rarely have been investigated. So far, eating-related self-regulation was shown to predict body mass changes in emerging adults (Zaremba Morgan et al. 2012). The present study highlights the role of behavior-specific self-regulation in predicting SSB intake as early as in preadolescence. Further, we observed quantitative and qualitative changes in the use of self-regulatory strategies. The strength of the associations increased significantly over the three stages of adolescence. Preadolescents regulated their SSB intake by means of strategies aimed at direct actions toward tempting food. In contrast, early and mid-adolescents controlled their SSB intake by means of the combination of self-regulatory strategies focusing on direct actions toward tempting food with self-regulatory strategies focusing on changing psychological meaning of tempting food. Although environmental factors may be proximal predictors in preadolescence, by mid-adolescence self-regulation becomes the most proximal predictor of SSB intake, as it mediates the effects of all environmental variables.

In line with our hypothesis, the direct relationships between at-home environment and intake became significantly weaker with age. These results corroborate theoretical approaches postulating changes in the character of direct relationships between family variables and behaviors across adolescence (Steinberg and Morris 2001). Our findings also corroborate results of systematic reviews indicating that the direct effects of family environment on obesity-related behaviors are weaker in 12- to 17-year-olds than among younger children (Cislak et al. 2012). On the other hand, results of the present study suggest that, among people who are 16 or 17 years old, the at-home environment remains related indirectly (with self-regulation acting as the mediator) to SSB. Recent research has indicated that self-regulatory beliefs play a mediating role

in associations between at-home accessibility or family encouragement and food intake in early and mid-adolescence (Kremers et al. 2006; Szczepanska et al. in press). The present study adds to that evidence and suggests that the character of these indirect (mediated) relationships changes from preadolescence to mid-adolescence.

The hypothesis assuming that the strength of direct relationships between the out-of-home environment and SSB intake would increase from preadolescence to mid-adolescence was partially supported. In particular, peers' social pressure became a significant predictor of SSB intake in mid-adolescence, whereas its effects were non-significant in preadolescence and early adolescence. This increasing size of the effect of peers' social pressure across adolescence is in line with theories assuming the increasing importance of peers throughout adolescence (Harris 1995; Steinberg and Morris 2001). It has to be noted, however, that the effects found in our study were small and emerged only in mid-adolescence. Previous research analyzing direct associations between peers pressure and SSB intake (for reviews see de Vet et al. 2011; Safron et al. 2011) also did not show strong support for the role of peers' influence, but those studies treated adolescents from different stages as one, homogenous age group. The present findings suggested that a lack of significant effects in earlier research may be due to combining pre-, early- and mid-adolescents into one group. Indeed, research focusing exclusively on mid-adolescents indicated that perceived peers' behaviors and descriptive norms are strong predictors of snack and sweetened beverage (Lally et al. 2011). As in the case of at-home environmental predictors, more indirect effects of the out-of-home environment on SSB intake were observed in early and mid-adolescence than in preadolescence.

Our findings have important practical implications for obesity prevention across adolescence. The intervention programs may benefit from targeting nutrition specific self-regulatory skills more often. Interventions aiming at obesity prevention may need to emphasize different environmental and self-regulatory variables, depending on the developmental stage of participants. Targeting environmental factors (e.g., accessibility of SSB, parental influence) and promoting self-regulatory strategy of controlling temptations may help preadolescents to reduce SSB intake whereas interventions designed for early and mid-adolescents may aim at enhancing self-regulatory strategies of suppression and controlling temptations.

Our research has several limitations. Due to cross-sectional design, any findings are preliminary. The final model may serve as a starting point for subsequent experimental research that would allow for causal conclusions. Future research should aim at the inclusion of objective indicators of behavior and test for the effects of other self-regulatory

strategies. Recent research has shown that adolescents may use a range of self-regulation strategies (de Vet et al. submitted) and it is not clear how these strategies may operate across stages of adolescence. The applied measures of environmental factors have limitations in terms of their psychometric properties (low between-items correlations). Longitudinal research is needed to further explain the complex changes in relationships between self-regulation, its environmental determinants, and eating behaviors across adolescence.

In spite of its limitations, our study offers insight into the dynamic relationships between the perceptions of environmental factors (at-home and out-of-home), self-regulation, and snacks and sweetened beverages (SSB) intake across adolescence. To date, research has shown significant associations between behavior-specific self-regulation and obesity-related outcomes among emerging adults (Zaremba Morgan et al. 2012) and has assumed uniformity of respective associations across adolescence (Kalavana et al. 2010). Our findings indicate that nutrition self-regulation is a relevant predictor of intake as early as in preadolescence. Further, it operates differently across the stages of adolescence. In particular, the strength of the association between self-regulation and SSB intake increases from preadolescence to mid-adolescence. SSB in preadolescence intake was regulated by means of immediate self-regulatory actions toward tempting food, whereas early and mid-adolescents controlled their SSB intake by means of a combination of immediate self-regulatory actions toward tempting food and strategies focusing on changing the psychological meaning of tempting food. Our approach, accounting for the mediating role of nutrition self-regulatory strategies, allows to capture the complex effects of the at-home and out-of-home environment on the consumption of energy-dense snacks in adolescence.

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**Author contributions** AL conceived of the study, participated in its design and coordination, performed the statistical analysis and drafted the manuscript; JDW conceived of the study, participated in its design and coordination and helped to draft the manuscript; EDV conceived of the study, participated in its design and coordination; AJ participated in design and coordination of the study and performed the measurement; NL participated in coordination of the study, performed the measurement and helped to draft the manuscript; FJ participated in design and coordination of the study and interpretation of the data; MP participated in the design and coordination of the study and performed the measurement; TG participated in the design and coordination of the study and performed the measurement; MGM participated in the design and coordination of the study and interpretation of the data; FMS participated in design and coordination of the study and performed the measurement. All authors read and approved the final manuscript.

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