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RESEARCH ARTICLE

Social Comparisons and Adolescent Body Misperception: Evidence From School Entry Cutoffs

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Received: 9 September 2024 | **Revised:** 18 April 2025 | **Accepted:** 16 May 2025

Keywords: health behaviors | social comparisons | weight

ABSTRACT

We provide novel evidence on the role of social comparisons in shaping adolescent body misperception. Using an instrumental variables approach leveraging variation in relative age generated by school entry cutoff months and data from the Health Behaviour in School-Aged Children study, we show that relatively younger students are more likely to describe their bodies as lighter than the clinically relevant BMI category implied by their reported heights and weights compared to their same-age counterparts who are relatively older within their respective classrooms. This result is driven by relatively younger students who are classified as normal weight for their age describing themselves as "too thin." We then show that relatively younger students are more likely to desire to gain weight, consume more calorie-dense foods, and report lower levels of physical activity. Overall, our results suggest that relatively younger students base their weight-related expectations and behaviors on their older peers.

JEL Classification: I1, J13, D91

1 | Introduction

Over the last 2 decades, policymakers and public health officials have been increasingly concerned about the relationship between body image and adolescent mental health (Murthy 2024). Adolescent body dissatisfaction has been linked to depression (Solomon-Krakus et al. 2017; Stevens et al. 2017), anxiety (Kostanski and Gullone 1998; Vannucci and Ohannessian 2018), and suicide ideation (Brausch and Muehlenkamp 2007; D.-S. Kim and Kim 2009). Researchers hypothesize that social media-driven comparisons (Rounsefell et al. 2020; Thai et al. 2023; Jarman et al. 2023) and weight-related pressure from friends and peers (Vincent and McCabe 2000; Fletcher 2014; Webb and Zimmer-Gembeck 2014; Fowler et al. 2021; J. Kim and Fletcher 2021) are key drivers of adolescent body dissatisfaction. At the same time, the rising rate of childhood obesity has altered parental and student perceptions on what it means to be healthy weight (Kantor 2007; Hernandez et al. 2010; Sugiyama et al. 2016). Yet the targeted nature of social media algorithms, potential self-selection on behalf of users, and endogenous friend group formation has made it difficult to isolate the role of peer comparisons in shaping body image and weight-related health behaviors.

We provide novel evidence on the relationship between social comparisons and adolescent body misperception by leveraging quasi-random variation in students' relative ages within a classroom generated by school entry cutoff months. Key to our analysis is the idea that students born immediately prior to the school entry cutoff month are expected to be almost a year younger than students within the same classroom who were born during the cutoff month. Given that adolescence is a period of significant physical development, this age difference implies that students born immediately prior to the cutoff month are also expected to weigh less than their peers born during the cutoff month. If students form their body image by comparing their bodies to the bodies of their classroom peers, relatively younger students' perceptions of their own bodies will be based, at least in part, on comparisons to the bodies of their older, larger peers.

To measure adolescent body image, we use data from the 2002–2018 waves of the Health Behaviour in School-Aged Children (HBSC) study. These surveys include a rich set of questions on students' weight-related behaviors and outcomes, including how the students describe their bodies and their body mass index (BMI). We use the difference between students' self-descriptions and the clinically relevant BMI category implied by their reported heights and weights as a measure of adolescent body image (Jiang et al. 2014; Shin and Nam 2015; Christoph et al. 2018; Smith and Zagorsky 2018; Carpenter and Churchill 2023). These surveys also contain information on weight-related behaviors, including dieting, food consumption, and physical activity. Importantly, for our purposes, they also include information on the students' ages (in months) at the time of the survey and classroom-specific identifiers, allowing us to identify students who are relatively older and younger than their classroom peers.

Parents often have discretion over when their children start school, so relative age within the classroom is not necessarily randomly determined. For example, parents may opt to hold their children back an extra year so that they are more mature when they first begin school (Black et al. 2011; Page et al. 2019; Cook and Kang 2020). To account for the possibility that this manipulation of relative age within the classroom may be correlated with our outcomes of interest—which may happen if parents opt to hold back less physically developed students—we adopt an instrumental variables identification strategy leveraging differences between the students' birth months and the school entry cutoff months in 33 European countries (Allen and Barnsley 1993; Bedard and Dhuey 2006; Fumarco and Baert 2019).[1] The idea behind this strategy is that while a student's expected relative age generated by the school entry cutoff should reasonably predict her actual relative age, it will be otherwise unrelated to the determinants of her body image.

We document several key findings. First, we show that relatively younger students (i.e., those with older peers) are more likely to describe their bodies as lighter than indicated by the clinically relevant World Health Organization BMI category implied by their reported heights and weights compared to students of the same age who are relatively older within their respective classrooms. We then show that this body misperception is driven by relative age influencing (i) how adolescents describe their bodies and (ii) their underlying BMIs. Second, we show that relatively younger students are more likely to report that they should try and gain weight. Third, we show that relatively younger students report consuming fewer low-calorie food items and more sweets and sugar sweetened beverages. These diet differences imply that students who are one standard deviation younger in relative age than their classmates consume 1365 more calories over the course of the year compared to students of the exact same age who are older within their respective classrooms. Finally, we find that relatively younger students report lower levels of physical activity than their relatively older counterparts. Overall, our results suggest that relatively younger students base their body image and weight-related behaviors on comparisons to their older peers.

Our paper builds on an economics literature studying how peer comparisons influence health behaviors. These studies have found that unfavorable social comparisons are associated with worse self-reported physical and mental health, increases in risky health behaviors, and increased risk of death (Eibner and Evans 2005; Pham-Kanter 2009; Balsa et al. 2014; Braghieri et al. 2022; Carpenter and Churchill 2023). Specifically studying weight-based social comparisons, prior work has shown that women with relatively thinner peers are more likely to engage in disordered eating behaviors (Costa-Font and Jofre-Bonet 2013; Arduini et al. 2019) and that relatively heavier adolescents experience greater behavioral problems (Huang et al. 2020).

We also add to literature specifically analyzing the effects of relative age on health behaviors. Leveraging variation in relative age generated by school entry cutoff dates, this work has shown that relatively younger adolescent girls (i.e., those with older peers) have elevated rates of substance use and risky sexual activity (Argys and Rees 2008; Black et al. 2011; Johansen 2021). Using the HBSC data to study peer social networks, Fumarco and Baert (2019) showed that relatively younger students were more likely to electronically communicate with their friends than their relatively older peers but had fewer face-to-face relationships. Meanwhile, Fumarco et al. (2020) showed that relatively older students reported greater life satisfaction, had higher self-reported general health, reported fewer psychosomatic complaints, and were less likely to be overweight than their relatively younger counterparts. This latter finding is in line with M. P. Anderson et al. (2011) who showed that United States students born immediately following the school entry cutoff date were less likely to be overweight, though the results were imprecisely estimated.

We build on this prior work in several important ways. First, we provide the first evidence that relative age influences how adolescents perceive their own bodies, highlighting the important role that social comparisons play in shaping adolescent body image. Second, we provide novel evidence that relatively younger students—who have older, heavier peers—describe themselves as being "too thin" and are more likely to report a desire to gain weight, even though they are also more likely to be overweight for their age. This result suggests that social comparisons may play an important role in the rising rates of overweight and obesity, given that individuals are comparing themselves to an increasingly overweight reference group (Chomitz et al. 2003; Maximova et al. 2008; Prina and Royer 2014; Madsen et al. 2021; Churchill 2024). Third, we provide new evidence that relative age is related to changes in nutrient intake and—consistent with a literature studying the effects of relative age on sports participation (Dhuey and Lipscomb 2008; Fumarco and Gabriel 2020)—further evidence that relative age leads to different levels of physical activity.

The rest of the paper proceeds as follows: Section 2 discusses the literature on how social comparisons affect economically meaningful outcomes, as well as the literature on the effects of relative age on educational and health outcomes. Section 3 describes the data and outlines our instrumental variables identification strategy. Section 4 presents the results, and Section 5 discusses and concludes.

2 | Literature Review

2.1 | Literature on Social Comparisons

Our paper contributes to an economics literature exploring the effects of various types of social comparisons on health outcomes. For example, several papers have studied the relationship between relative socioeconomic position—a type of social comparison—and risky health behaviors (Luttmer 2005; Pham-Kanter 2009; Mangyo and Park 2011). Eibner and Evans (2005) showed that individuals with less income than those in their reference group had worse self-reported health, higher body mass index, and increased risk of death. Similarly, Balsa et al. (2014) found that adolescent males in the AddHealth data in a relatively lower socioeconomic position than their peers were more likely to use alcohol, had heavier alcohol use, and were more likely to smoke. In another strand of literature, scholars have begun exploring the effects of social media use on social comparisons and mental health. Using both experimental (Allcott et al. 2020; Mosquera et al. 2020) and quasi-experimental methods (Braghieri et al. 2022), these papers have shown that social media use harms mental health, presumably by fostering unfavorable social comparisons.

We also add to a smaller literature documenting the relationship between relative bodyweight and economically meaningful health outcomes. For example, Costa-Font and Jofre-Bonet (2013) showed that women with heavier peers were less likely to be anorexic, while Arduini et al. (2019) found that teen girls with relatively thinner peers were more likely to perceive themselves as heavier than their BMI and to engage in disordered eating behaviors. Using the AddHealth data, Brunello et al. (2020) showed that an increase in peers' average genetic predisposition to high BMI raised the probability that adolescents underestimated their weight and increased obesity among adolescent girls. There is also evidence that adolescents' relative position in the weight distribution can influence their self-esteem and other non-cognitive outcomes. Leveraging variation in relative body size induced by movements between MSAs, Huang et al. (2020) showed that adolescents who moved to thinner areas—and therefore became relatively heavier—experienced increased behavioral problems.

2.2 | Literature on Relative Age

This paper also builds on a large body of evidence studying the effects of relative age on education, labor market, and health outcomes (Allen and Barnsley 1993; Bedard and Dhuey 2006; Evans et al. 2010; Page et al. 2019). One complication in this literature is that students who are relatively older than their peers are also older in the absolute sense. For example, if a 15.5-year-old performs better on an exam than her 15.0-year-old classmate, it is unclear whether this difference was because of a benefit to being relatively older within the classroom or because the student was simply 0.5 years older at the time of the exam. Using a variety of identification strategies to disentangle these relative and absolute age effects, researchers have generally found large, positive effects of absolute age at the time of the exam and smaller positive effects of starting school younger (Black et al. 2011; Cascio and Whitmore Schanzenbach 2016; Peña 2017).

Examining the effects of relative age on risky health behaviors, Argys and Rees (2008) used data from the National Longitudinal Survey of Youth—1997 and state-level variation in kindergarten starting dates to show that relatively younger adolescent girls (i.e., those with older peers) were more likely to use marijuana, drink alcohol, and smoke cigarettes. More recently, Johansen (2021) used Danish register data to show that being young-for-grade increased the probabilities that a girl had an abortion and experienced alcohol poisoning during adolescence.[2] Interestingly, neither paper found a relationship between relative age and adolescent boys' risky health behaviors. Particularly relevant for our context, M. P. Anderson et al. (2011) found that students in the Early Childhood Longitudinal Study—Kindergarten Cohort of 1998 who were born immediately following the school entry date were less likely to be classified as overweight, though the results were statistically insignificant.

There is also evidence that relative age can influence social networks and overall life satisfaction. Using Health Behaviour in School-Aged Children data and leveraging variation generated by school entry cutoff dates, Fumarco and Baert (2019) found that, after controlling for absolute age, relatively younger students were more likely to electronically communicate with their friends than their relatively older peers but had fewer face-to-face relationships.[3] Similarly, Fumarco et al. (2020) showed that relatively older students reported greater life satisfaction and health, and in a contemporaneous working paper Fumarco et al. (2024) explore the relationship between relative age and eating behaviors.

3 | Data Description and Empirical Approach

3.1 | Data: Health Behaviour in School-Aged Children, 2002–2018

We obtain data on adolescent body image from five waves of the Health Behaviour in School-Aged Children (HBSC) study. HBSC is a cross-national study of adolescents across Europe and North America conducted in collaboration with the World Health Organization. Data are collected from school-based surveys using a standard methodology to produce nationally representative estimates of 11-, 13-, and 15-year-old adolescents. While the surveys have been fielded every 4 years since 1983/84, only the 2001/02, 2005/06, 2009/10, 2013/14, and 2017/18 waves are publicly available at the time of this study.

The HBSC surveys collect information on a broad range of health behaviors and outcomes, including body image, weight-related behaviors, social dynamics, substance use, and physical health. Students are primarily sampled via random selection of classes within a targeted school, with most schools having only one classroom sampled.[4] The HBSC surveys identify two preferred sampling techniques. The first is simple random sampling of school classes using a computerized random sampling procedure. The second is the systematic sampling of every *n*th class from a list using a random starting point. HBSC will also use probability proportional sampling whereby the size of the school is taken into account. The HBSC datasets include sample weights to produce nationally representative estimates. These data have previously been used by economists (Fumarco et al. 2020; Gangl 2024; Hallaq 2024), psychologists (Horanicova et al. 2022; Paniagua et al. 2022), and a broad collection of public health researchers (Elgar et al. 2019; Dierckens et al. 2022; Hu et al. 2023).

For our purposes, these data offer a few key advantages. First, they include information on each student's age (in months) at the time of the survey, allowing us to identify students in the classroom who are relatively older or younger.[5] Second, these data include information on students from a wide range of absolute ages, allowing us to separately identify the effects of relative age and absolute age. Finally, the cross-country nature of the data allows us to exploit additional variation in the school entry cutoff month, increasing confidence that the relative age effects we identify are not being driven by unobserved factors correlated with birth month.

We calculate a student's relative age as the difference between age (in months) of the student and the oldest "regular" student within the same class (Fumarco and Baert 2019; Fumarco et al. 2020). To identify regular students, we first find the modal year of birth for students born in the second academic quarter, given that these students are least likely to be in the "wrong" class due to retention or being "redshirted" (i.e., held back a year) by their parents. We then use this birth year and the relevant school entry cutoff month to identify older students (i.e., those that repeated a grade or were redshirted) and younger students (i.e., those that started school early). The remaining students are regular students (i.e., those in the expected class).[6] If all students entered on time and did not repeat a grade, relative age would vary from −12 to 0 with a mean of −6. However, Figure 1 shows that the data are right skewed with an average relative age of −3.8, consistent with prior work showing that parents may strategically choose to delay enrolling their children in school (Allen and Barnsley 1993; Bedard and Dhuey 2006; Evans et al. 2010; Page et al. 2019).[7] We report summary statistics for our explanatory variables of interest and our dependent variables in Table 1.[8]

Our main goal is to understand whether and how social comparisons influence adolescent body image. To do so, we follow the literature and construct a measure of weight perception that compares how adolescents describe their bodies relative to their self-reported BMI status (Jiang et al. 2014; Shin and Nam 2015; Christoph et al. 2018; Smith and Zagorsky 2018; Carpenter and Churchill 2023). As part of the survey, students are asked whether they think that their body is (i) "much too thin," (ii) "a bit too thin," (iii) "about the right size," (iv) "a bit too fat," or (v) "much too fat." Students are also asked about their height and bodyweight, allowing us to calculate their self-reported BMIs (weight in kg/height in squared meters). To account for growth rates throughout childhood and adolescence (Daniels 2009), we use the World Health Organization's 2007 sex-specific BMI-for-age (in months) thresholds to determine whether an adolescent is classified as (i) severely thin, (ii) thin, (iii) normal weight, (iv) overweight, or (v) obese based on the BMI variable constructed from reported height and weight measures and the corresponding BMI-for-age threshold. BMI is an imperfect measure of excess bodyweight, in part because it does not distinguish between fat mass and lean muscle mass (Must and Anderson 2006; Daniels 2009). However, it correctly identifies adolescents who are not at risk for overweight or obesity and is

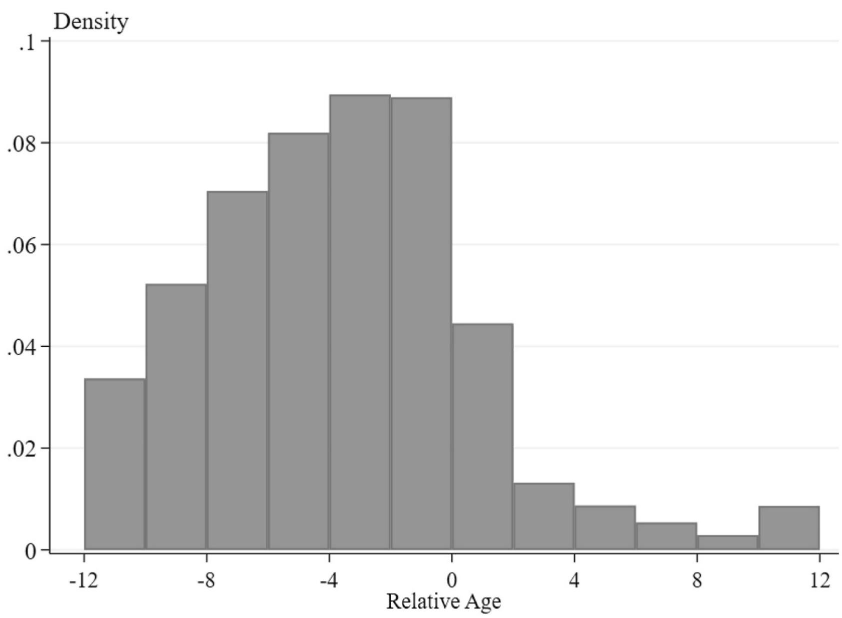


FIGURE 1 | Distribution of relative age. *Source:* Health behaviour in school-aged children, 2002–2018. The figure plots the average relative age (in months) for students based on their birth month relative to the school entry cutoff. The endpoints are binned at −12 and 12 for the sake of the graph, though we use the non-binned values in all analyses. The summary statistics utilize the sample weights.

TABLE 1 | Summary statistics.

	Mean	Std. dev.	Minimum	Maximum	Observations
Age variables					
Relative age	−3.812	5.328	−65	60	572,889
Absolute age	13.549	1.644	9.833	17	572,889
Expected relative age	5.505	3.354	0	11	572,889
Average classmate age	13.550	1.625	9.063	17	572,889
Body image					
Perception	−0.011	0.769	−4	4	462,675
Lenient	0.213	0.410	0	1	462,675
Accurate	0.578	0.494	0	1	462,675
Harsh	0.209	0.407	0	1	462,675
Self-description					
Too thin	0.147	0.354	0	1	554,546
Right size	0.558	0.497	0	1	554,546
Too fat	0.294	0.456	0	1	554,546
Weight outcomes					
BMI	19.389	3.407	5.951	79.861	476,401
Thin	0.047	0.211	0	1	476,401
Normal weight	0.772	0.419	0	1	476,401
Overweight	0.181	0.385	0	1	476,401
Obese	0.040	0.196	0	1	476,401
Dieting behaviors					
On a diet	0.145	0.352	0	1	454,163
No reason to diet	0.561	0.496	0	1	454,163
Should diet to gain weight	0.202	0.402	0	1	454,163
Should diet to lose weight	0.091	0.288	0	1	454,163
Number of times eating					
Fruits	4.940	3.188	0	10	568,220
Vegetables	4.759	3.078	0	10	568,220
Sweets	3.942	3.086	0	10	568,220
Soda	3.239	3.237	0	10	568,220
Physical activity					
No. Days active for 60 min	4.088	2.045	0	7	560,575
No. Times exercising	3.321	2.330	0	7	465,717
No. Hours exercising	2.520	2.223	0	7	358,910

Note: The summary statistics utilize the sample weights.
Source: Health behaviour in school-aged children, 2002–2018.

more accurate at detecting at-risk adolescents than alternative measures commonly employed by parents and clinicians (Malina and Katzmarzyk 1999; Perrin et al. 2004; Reilly 2010; Güngör 2014; Javed et al. 2014).[9]

We code the self-described body type measure and the BMI status variable to both take on values 1 through 5, and our measure of body image is the difference between these two variables. This measure of weight perception will be positive for students whose description of their body is heavier relative to the clinically relevant WHO BMI categories suggested by their reported heights and weights, zero for those whose self-descriptions are consistent with the clinically relevant WHO BMI categories suggested by their reported heights and weights, and negative for students whose description of their body is lighter relative to the clinically relevant WHO BMI categories suggested by their reported heights and weights. We show in Figure 2 that approximately 20% of adolescents in the HBSC data describe themselves as lighter than indicated by their BMI status, 60% describe themselves in a way that is consistent with their BMI status, and 20% describe themselves as heavier than indicated by their BMI status.

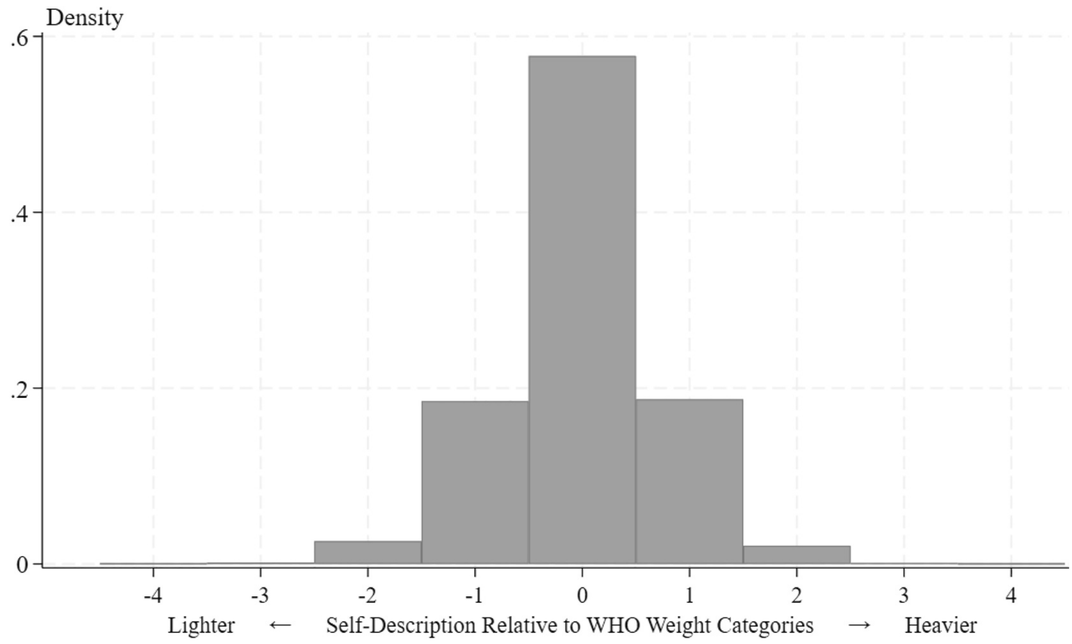


FIGURE 2 | Distribution of body image. *Source:* Health behaviour in school-aged children, 2002–2018. The figures plot the distribution of body image perception. This value is constructed by taking the difference between a variable denoting how the student described his or her body and a variable denoting the clinically relevant WHO BMI status implied by the student's reported height and weight. The former variable takes on the value of 1 if the student describes his or her body as "much too thin," 2 if the student describes his or her body as "a bit too thin," 3 if the student describes his or her body as "about the right size," 4 if the student describes his or her body as "a bit too fat," and 5 if the student describes his or her body as "much too fat." The latter variable takes on the value of 1 if the student is classified as "severely thin," 2 for those classified as "thin," 3 for those classified as "normal weight," 4 for those classified as "overweight," and 5 for those classified as "obese."

Unfortunately, the HBSC data do not contain objectively collected measures of height and weight. While prior work has used datasets containing both clinically measured and self-reported anthropometric outcomes to develop methods of correcting self-reported data in the U.S. (Cawley and Burkhauser 2008; Cawley et al. 2015), we are unaware of any data which would permit a similar procedure for all the countries in the HBSC data. It is worth noting that because adolescent BMI status is based on BMI-for-age (in months) thresholds, rather than a single numeric value for all ages, adolescents would likely face difficulty in adjusting their reporting to target a specific status. However, because we do not have an objective measure of weight, our measure of weight perception should be interpreted as capturing the difference between the verbal descriptors and numeric values that adolescents use to describe their bodies.

3.2 | Empirical Approach: Instrumental Variables

To study the relationship between relative age and body misperception, we could estimate the following naïve ordinary least squares regression:

$$Y_{iact} = \alpha_0 + \alpha_1 \cdot RELATIVE\ AGE_a + \alpha_2 \cdot AGE_a + \alpha_3 \cdot X'_{iact} + \alpha_4 \cdot C_c + \alpha_5 \cdot T_t + \varepsilon_{iact} \quad (1)$$

where the dependent variable, Y, is the outcome of interest for adolescent i of age a from country c and survey year t. In this setting, the vector X includes individual-level demographic characteristics that might influence body misperception and various weight-related health behaviors, including indicators for month-of-birth, sex, whether the adolescent's mother and/or father are present in the household (P. M. Anderson et al. 2003; P. M. Anderson 2012), and socioeconomic status (Cawley 2015).[10] We also include country fixed effects, C, and survey wave fixed effects, T.

The independent variables of interest are (i) *RELATIVE AGE*, which captures the change in the outcome variable associated with being 1 month older than the typical classroom peer, and (ii) *AGE*, which captures the change in the outcome variable associated with being one additional month older. One potential issue with this approach is that relative age can be manipulated in a way that may be correlated with factors affecting the outcomes of interest. For example, parents may time conception to assure a particular season of birth, parents may choose to delay enrolling their eligible child in school for a year, or the child may repeat a grade due to poor academic performance. In our context—where we are examining changes in body image—this could prove problematic if parents base school starting age on their child's physical development. For example, parents may opt to hold their children back if they are physically smaller. Likewise, they may decide to put their child in school earlier if they are more physically developed. Given the correlation between relative age and physical size, this endogeneous decision-making on the part of parents may subsequently influence their children's relative size and body image.

To address the potential endogeneity inherent in relative age, we follow the literature and leverage plausibly exogeneous variation generated by the country-specific school entry cutoff month using an instrumental variables approach (Datar 2006; Black et al. 2011; Peña and Duckworth 2018; Johansen 2021).[11] The idea behind this approach is that students born just after the school entry cutoff month will be nearly a year older than those born just before the cutoff, though they will both be part of the same academic class. For example, Figure 3 shows a clear negative relationship between students' birth months relative to the school entry cutoff and average relative age, with students born in the cutoff month having an average relative age of −1.4 while those born 11 months later had an average relative age of −7.3 (Panel A). Interestingly, we also observe a systematic relationship between birth month relative to the school entry cutoff and body perception (Panel B). While adolescents born near the school entry cutoff month, on average, describe themselves in a way that is consistent with the clinically relevant WHO BMI category implied by their reported heights and weights, those born further from the cutoff—who are likely to be relatively younger and have older, heavier peers—described themselves as lighter than their relevant BMI-for-age category.

Because many of the endogeneity concerns related to relative age could also affect the absolute age of the adolescent, we also instrument for absolute age with the average age of students from the same country, who were interviewed in the same survey wave, were in the same classroom, and were born during the same quarter of the academic year (Peña and Duckworth 2018; Fumarco and Baert 2019; Fumarco et al. 2020).

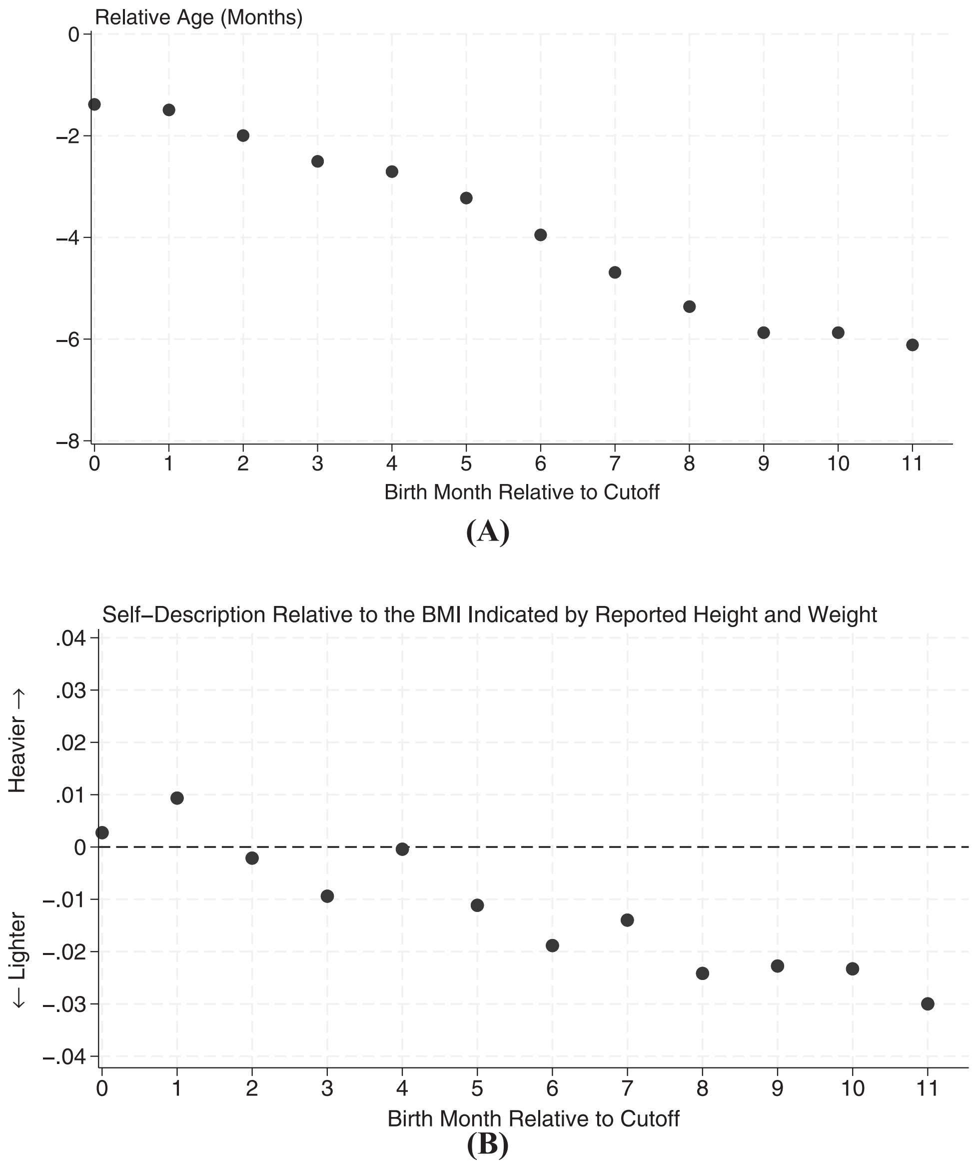


FIGURE 3 | Adolescents born further from the school entry cutoff month are relatively younger and describe themselves lighter than the clinically relevant who weight categories suggested by their reported heights and weights. *Source*: Health behaviour in school-aged children, 2002–2018. Panel A plots the average relative age (in months) for students based on their birth month relative to the school entry cutoff. Panel B plots the average difference between how students described their bodies (i.e., much too thin, a bit too thin, about the right size, a bit too fat, and much too fat) and the clinically relevant WHO weight categories indicated by their reported height and weight (severely thin, thin, normal weight, overweight, and obese). The summary statistics utilize the sample weights.

Using these two instruments, we estimate our first stage regression relating the endogeneous variables (i.e., relative age and age) to our two instruments:

$$\begin{aligned} \text{ENDOGENEOUS}_{iact} = \delta_0 + \delta_1 \\ \cdot \textit{BIRTH MONTH RELATIVE TO CUTOFF}_{ic} \\ + \delta_2 \cdot \textit{AVG AGE}_{iact} + \delta_3 \cdot X'_{iact} \\ + \delta_4 \cdot C_c + \delta_5 \cdot T_t + \varepsilon_{iact} \end{aligned} \quad (2)$$

where *BIRTH MONTH RELATIVE TO CUTOFF* takes on the value of 0 for those born in the cutoff month through −11 for those born immediately prior to the cutoff month. Meanwhile, *AVG AGE* is the average age of the student's comparable peers. We then estimate the second stage equation:

$$\begin{aligned} Y_{iact} = \beta_0 + \beta_1 \cdot \widehat{\textit{RELATIVE AGE}}_a + \beta_2 \\ \cdot \widehat{AGE}_a + \beta_3 \cdot X'_{iact} + \beta_4 \cdot C_c + \beta_5 \cdot T_t + \varepsilon_{iact} \end{aligned} \quad (3)$$

where $\widehat{\textit{RELATIVE AGE}}$ and $\widehat{AGE}$ indicate the predicted values of relative age and absolute age obtained from the first stage equations. Throughout the paper, we report these two-stage least squares (2SLS) estimates and cluster standard errors at the classroom level.[12]

4 | Results

4.1 | Effects on Body Misperception

We begin in Table 2 examining the relationship between expected relative age—which is calculated based on birth month relative to the school entry cutoff month—and relative age within the classroom. We find that students born 1 month closer to the school entry cutoff are estimated to be 0.41 months older (column 1). Next, we explore the relationship between relative age and body perception. The dependent variable in columns 2–4 measures the difference between how students describe their bodies and their corresponding BMI statuses calculated from their reported heights and weights. This variable takes on a negative value when a student describes herself as lighter than indicated by the clinically relevant WHO BMI status implied by her reported height and weight, zero when her self-description is aligned with her BMI status, and a positive value when her self-description is heavier than indicated by her BMI status. For ease of interpretation, we scale the estimates to reflect a one standard deviation reduction in relative age (approximately 5.3 months).

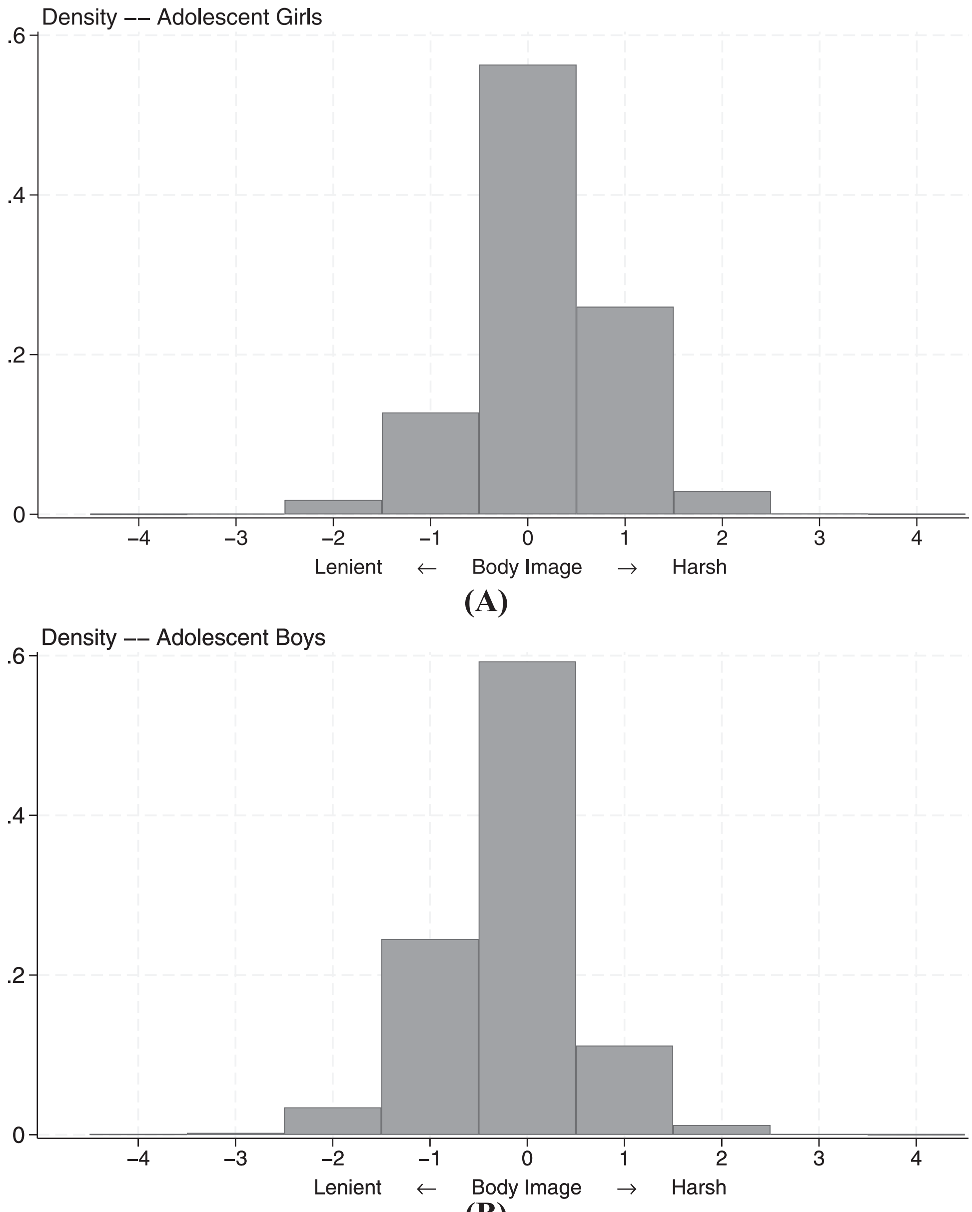
These results suggest that relatively younger students are more likely to describe themselves as lighter than indicated by their

TABLE 2 | Two-state least squares results showing that relatively younger students are more likely to describe themselves as lighter than the clinically relevant BMI category implied by their reported heights and weights compared to their same-age counterparts who are relatively older within their classrooms.

	(1)	(2)	(3)	(4)
Outcome →	Relative age	Self-perception relative to the clinically relevant BMI category implied by reported height and weight		
Specification →	1st stage	OLS	Reduced form	2SLS
Expected relative age	0.414***			
	(0.008)			
1 SD ↓ relative age		−0.007***		−0.029***
		(0.001)		(0.005)
1 SD ↓ expected relative age			−0.012***	
			(0.002)	
F-statistic				4854.701
Mean	−3.79	−0.010	−0.010	−0.010
Standard deviation	5.29	0.768	0.768	0.768
Observations	462,765	462,765	462,765	462,765

Note: The dependent variable in column 1 is the student's relative age within the classroom. The dependent variable in columns 2–4 is the student's self-perception relative to his or her BMI. This value is constructed by taking the difference between a variable denoting how the student described his or her body and a variable denoting the student's BMI status corresponding to his or her reported height and weight. The former variable takes on the value of 1 if the student describes his or her body as "much too thin," 2 if the student describes his or her body as "a bit too thin," 3 if the student describes his or her body as "about the right size," 4 if the student describes his or her body as "a bit too fat," and 5 if the student describes his or her body as "much too fat." The latter variable takes on the value of 1 if the student is classified as "severely thin," 2 for those classified as "thin," 3 for those classified as "normal weight," 4 for those classified as "overweight," and 5 for those classified as "obese." Positive values indicate that the student described his or her body as heavier than indicated by the clinically relevant WHO BMI category implied by his or her reported height and weight. The independent variable of interest in column 1 is the student's expected relative age calculated from his or her birth month relative to the school entry cutoff. The independent variable of interest in columns 2 and 4 is the student's relative age within the classroom. The independent variable of interest in column 3 is the student's expected relative age. Columns 1 and 2 are estimated via the ordinary least squares specification shown in Equation (1). Column 3 is estimated via the ordinary least squares specification shown in Equation (2). Finally, column 4 is estimated via the two-stage least squares specification shown in Equation (3). The estimates utilize the sample weights. Standard errors, shown in parentheses, are clustered at the classroom level.
Source: Health behaviour in school-aged children, 2002–2018.
*$p < 0.10$.
**$p < 0.05$.
***$p < 0.01$.

BMI status compared to their same-age counterparts who are relatively older within their respective classrooms (column 2). Of course, relative age can be endogenously determined by parents opting to hold their children back a year, and the characteristics associated with this decision may also be correlated with household weight-related attitudes that shape adolescents' body misperception. For example, parents may perceive their relatively younger—and physically smaller—children as less mature or worry that they will be targeted for bullying. Alternatively, parents may view their relatively older—and physically larger—children as ready to begin schooling earlier. To account for this possibility, we instrument for relative age with the difference between students' birth months and the relevant school entry cutoff month. Consistent with the naïve ordinary least squares estimates, the reduced-form evidence indicates that students who are born further from the school entry cutoff month describe themselves as lighter than the clinically relevant WHO BMI category implied by their reported heights and weights (column 3). Finally, our two-stage least squares results indicates that a one standard deviation reduction



(A)

(B)

FIGURE 4 | Distribution of body image, by sex. *Source:* Health behaviour in school-aged children, 2002–2018. The figures plot the distribution of body image perception for adolescent girls (Panel A) and adolescent boys (Panel B). This value is constructed by taking the difference between a variable denoting how the student described his or her body and a variable denoting the student's BMI status as determined by the clinically relevant WHO category implied by his or her reported height and weight. The former variable takes on the value of 1 if the student describes his or her body as "much too thin," 2 if the student describes his or her body as "a bit too thin," 3 if the student describes his or her body as "about the right size," 4 if the student describes his or her body as "a bit too fat," and 5 if the student describes his or her body as "much too fat." The latter variable takes on the value of 1 if the student is classified as "severely thin," 2 for those classified as "thin," 3 for those classified as "normal weight," 4 for those classified as "overweight," and 5 for those classified as "obese."

in relative age is associated with a 0.029-unit reduction in body perception—indicating that relatively younger students are describing themselves as lighter than their corresponding BMI status. This result demonstrates that social comparisons can play an important role in shaping body image. Overall, the ordinary least squares, reduced form, and two-stage least squares estimates in Table 2 all indicate that relatively younger students are more likely to describe themselves as lighter than the

TABLE 3 | Two-stage least squares relationship between relative age and body image, by sex.

Sample →	**(1) All adolescents**	**(2) Adolescent girls**	**(3) Adolescent boys**
1 SD ↓ relative age	−0.029***	−0.025***	−0.033***
	(0.005)	(0.006)	(0.007)
F-statistic	4854.70	3869.92	2933.72
Mean	−0.011	0.156	−0.184
Standard deviation	0.769	0.758	0.741
Observations	462,765	236,030	226,735

Note: The dependent variable is the student's self-perception relative to his or her BMI. This value is constructed by taking the difference between a variable denoting how the student described his or her body and a variable denoting the student's BMI status corresponding to his or her reported height and weight. The former variable takes on the value of 1 if the student describes his or her body as "much too thin," 2 if the student describes his or her body as "a bit too thin," 3 if the student describes his or her body as "about the right size," 4 if the student describes his or her body as "a bit too fat," and 5 if the student describes his or her body as "much too fat." The latter variable takes on the value of 1 if the student is classified as "severely thin," 2 for those classified as "thin," 3 for those classified as "normal weight," 4 for those classified as "overweight," and 5 for those classified as "obese." Positive values indicate that the student described his or her body as heavier than indicated by the clinically relevant WHO BMI category implied by his or her reported height and weight. The estimates are obtained using a two-stage least squares strategy shown in Equation (3) where birth month relative to the school entry cutoff is an instrument for relative age and the average age of comparable classroom peers is used as an instrument for absolute age. Column 1 examines all adolescents, column 2 examines adolescent girls, and column 3 examines adolescent boys. The estimates utilize the sample weights. Standard errors, shown in parentheses, are clustered at the classroom level.
Source: Health behaviour in school-aged children, 2002–2018.
*$p < 0.10$.
**$p < 0.05$.
***$p < 0.01$.

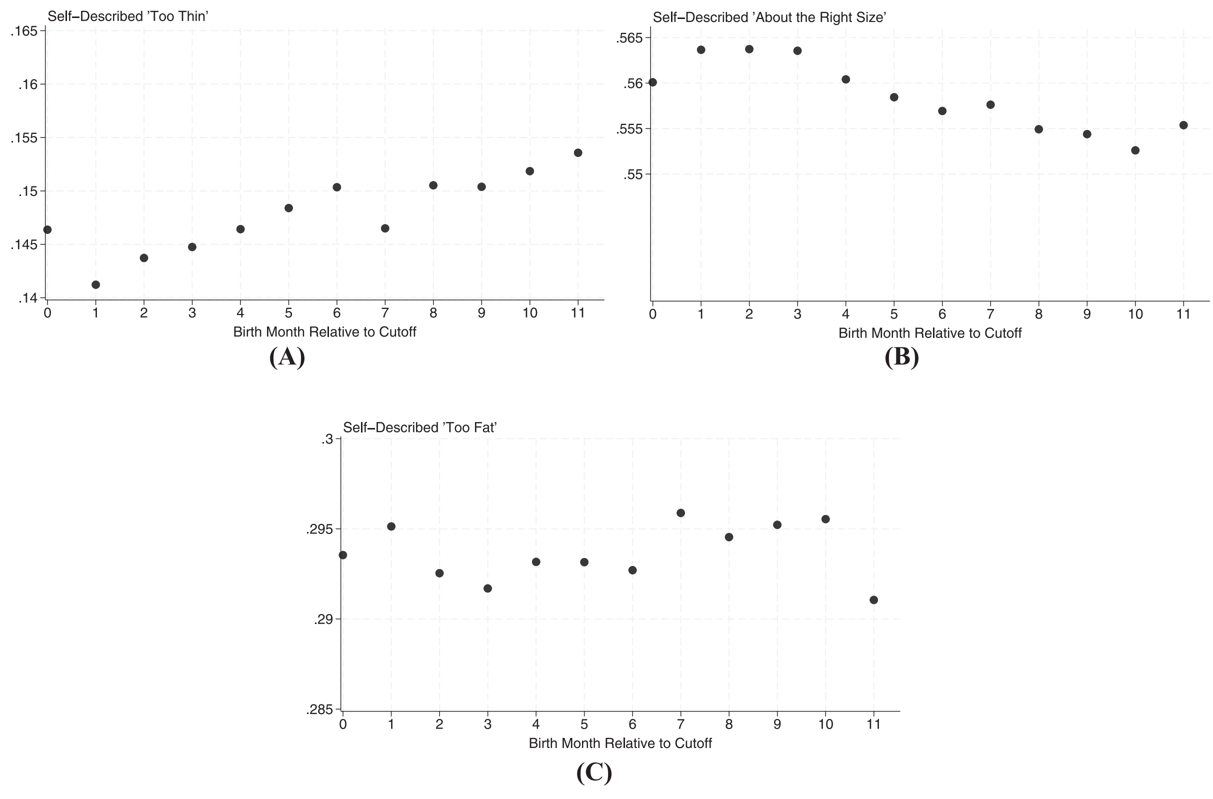


FIGURE 5 | Descriptive trends showing that adolescents born further from the school entry cutoff month are more likely to describe themselves as being too thin. *Source:* Health behavior in school-aged children, 2002–2018. Panel A plots the share of students who described themselves as "much too thin" or "a bit too thin" based on their birth month relative to the school entry cutoff. Panel B plots the share of students who described themselves as "about the right size," and Panel C plots the share of students who described themselves as "a bit too fat" or "much too fat." The summary statistics utilize the sample weights. Standard errors are clustered at the classroom level.

clinically relevant WHO BMI category indicated by their reported heights and weights.[13,14]

Because students born near the school entry cutoff are less likely to be regular students (i.e., they are more likely to have started early, delayed schooling for a year, or repeated a grade), potentially violating our identification strategy's monotonicity assumption, we show in Appendix Table 6 that our results are robust to iteratively dropping students on either side of the cutoff. Likewise, we show in Appendix Table 7 that the results are robust to limiting our sample to each of the survey waves, indicating that the relationship is not being driven by secular trends occurring throughout our survey period (e.g., rising obesity rates or increased use of social media).[15,16]

Prior work has found that concerns about body size and weight are more salient for adolescent girls and young women compared to their male counterparts (Costa-Font and Jofre-Bonet 2013; Arduini et al. 2019; Carpenter and Churchill 2023), suggesting that the relationship between relative age and body misperception may vary by sex. In line with this work, Figure 4 shows that adolescent girls are more likely to describe themselves as heavier than the BMI status implied by their reported heights and weights (Panel A) while adolescent boys are more likely to describe themselves as lighter (Panel B). Yet Table 3 shows that a one standard deviation reduction in relative age is associated with a 0.025-unit reduction in self-description relative to body image among adolescent girls (column 2) and a 0.033-unit reduction among adolescent boys (column 3). These results indicate that relatively younger adolescent boys are the group most inclined to view themselves as lighter than indicated by their BMI status.[17,18]

4.2 | Components of Body Misperception: Self-Descriptions and Body Mass Index

Our measure of body misperception compares students' self-reported body types to the clinically relevant BMI category

TABLE 4 | Two-stage least squares relationship between relative age and self-described body type, by BMI status.

Self-description →	**(1) Too thin**	**(2) About the right size**	**(3) Too fat**
Panel A: Sample is thin adolescents			
1 SD ↓ relative age	0.075***	−0.068***	−0.007
	(0.018)	(0.017)	(0.009)
F-statistic	381.94	381.94	381.94
Mean	0.480	0.457	0.063
Standard deviation	0.500	0.498	0.244
Observations	21,645	21,645	21,645
Panel B: Sample is normal weight adolescents			
1 SD ↓ relative age	0.016***	−0.014***	−0.002
	(0.003)	(0.004)	(0.003)
F-statistic	4239.57	4239.57	4239.57
Mean	0.160	0.622	0.219
Standard deviation	0.366	0.485	0.413
Observations	357,797	357,797	357,797
Panel C: Sample is overweight and obese adolescents			
1 SD ↓ relative age	−0.002	−0.009	0.011
	(0.002)	(0.007)	(0.007)
F-statistic	1876.14	1876.14	1876.14
Mean	0.024	0.329	0.647
Standard deviation	0.152	0.470	0.478
Observations	83,323	83,323	83,323

Note: The dependent variable in column 1 is an indicator for whether the student described his/her body as "much too thin" or "a bit too thin." The dependent variable in column 2 is an indicator for whether the student described his/her body as being "about the right size." The dependent variable in column 3 is an indicator for whether the student described his/her body as being "a bit too fat" or "much too fat." The estimates are obtained using a two-stage least squares strategy shown in Equation (3) where birth month relative to the school entry cutoff is an instrument for relative age and the average age of comparable classroom peers is used as an instrument for absolute age. The sample is stratified by the WHO BMI category implied by the students' reported heights and weights. Panel A examines thin adolescents, Panel B examines normal weight adolescents, and Panel C examines overweight and obese adolescents. The estimates utilize the sample weights. Standard errors, shown in parentheses, are clustered at the classroom level.
Source: Health behaviour in school-aged children, 2002–2018.
*$p < 0.10$.
**$p < 0.05$.
***$p < 0.01$.

implied by their reported heights and weights (Jiang et al. 2014; Shin and Nam 2015; Christoph et al. 2018; Smith and Zagorsky 2018; Carpenter and Churchill 2023). As a result, relative age can influence body misperception by (i) altering how students describe their bodies without affecting their self-reported BMIs, (ii) changing students' self-reported BMIs without affecting how they describe their bodies, or (iii) altering how students describe their bodies and changing their self-reported BMIs. In this section, we explore the pathways through which relative age influences body misperception.

Figure 3 provided descriptive evidence that students born near the school entry cutoff month generally describe themselves in a way that was consistent with their BMI category, while those born further from the cutoff describe themselves as lighter than their respective categories (Panel B). Likewise, we showed in Table 3 that relatively younger students (i.e., those with older and presumably heavier peers) are more likely to describe themselves as lighter than indicated by the clinically relevant WHO BMI category suggested by their reported heights and weights. Indeed, Figure 5 shows that students born further from the school entry cutoff month are more likely to describe themselves as "too thin" (Panel A) and less likely to describe themselves as being "about the right size" (Panel B). There is no clear visual association between birth month relative to the school entry cutoff month and the share of adolescents describing themselves as "too fat" (Panel C).

In Table 4, we explore whether and how the relationship between relative age and weight misperception varies by BMI category. The dependent variable in column 1 is an indicator for whether an adolescent describes herself as "too thin," the dependent variable in column 2 is an indicator for whether an adolescent describes herself as "about the right size," and the dependent variable in column 3 is an indicator for whether the adolescent describes herself as "too fat." Panel A limits the

TABLE 5 | Two-stage least squares relationship between relative age and self-described body type, by sex and BMI status.

	(1)	(2)	(3)	(4)	(5)	(6)
Sample →	**Adolescent girls**			**Adolescent boys**		
Self-description →	**Too thin**	**About the right size**	**Too fat**	**Too thin**	**About the right size**	**Too fat**
Panel A: Sample is thin adolescents						
1 SD ↓ relative age	0.048**	−0.055***	0.007	0.116***	−0.089***	−0.028**
	(0.021)	(0.021)	(0.012)	(0.029)	(0.029)	(0.012)
F-statistic	276.18	276.18	276.18	144.37	144.37	144.37
Mean	0.474	0.445	0.081	0.487	0.470	0.043
Standard deviation	0.499	0.497	0.273	0.500	0.499	0.203
Observations	11,579	11,579	11,579	10,066	10,066	10,066
Panel B: Sample is normal weight adolescents						
1 SD ↓ relative age	0.013***	−0.012***	−0.001	0.018***	−0.016***	−0.003
	(0.003)	(0.005)	(0.004)	(0.005)	(0.006)	(0.004)
F-statistic	3340.55	3340.55	3340.55	2366.74	2366.74	2366.74
Mean	0.120	0.579	0.300	0.205	0.670	0.124
Standard deviation	0.325	0.494	0.458	0.404	0.470	0.330
Observations	192,496	192,496	192,496	165,301	165,301	165,301
Panel C: Sample is overweight and obese adolescents						
1 SD ↓ relative age	−0.001	−0.002	0.004	−0.002	−0.014	0.016*
	(0.002)	(0.009)	(0.009)	(0.003)	(0.010)	(0.010)
F-statistic	1049.61	1049.61	1049.61	1105.06	1105.06	1105.06
Mean	0.013	0.221	0.765	0.030	0.397	0.573
Standard deviation	0.115	0.415	0.424	0.171	0.489	0.495
Observations	31,955	31,955	31,955	51,368	51,368	51,368

Note: The dependent variable in columns 1 and 4 is an indicator for whether the student described his/her body as "much too thin" or "a bit too thin." The dependent variable in columns 2 and 5 is an indicator for whether the student described his/her body as being "about the right size." The dependent variable in columns 3 and 6 is an indicator for whether the student described his/her body as being "a bit too fat" or "much too fat." The estimates are obtained using a two-stage least squares strategy shown in Equation (3) where birth month relative to the school entry cutoff is an instrument for relative age and the average age of comparable classroom peers is used as an instrument for absolute age. The sample is stratified by the WHO BMI category implied by the students' reported heights and weights. Panel A examines thin adolescents, Panel B examines normal weight adolescents, and Panel C examines overweight and obese adolescents. Columns 1–3 limit the sample to adolescent girls, while columns 4–6 limit the sample to adolescent boys. The estimates utilize the sample weights. Standard errors, shown in parentheses, are clustered at the classroom level.
Source: Health behaviour in school-aged children, 2002–2018.
*$p < 0.10$.
**$p < 0.05$.
***$p < 0.01$.

sample to adolescents whose reported heights and weights imply that they are classified as thin for their age, Panel B limits the sample to adolescents whose reported heights and weights imply that they are classified as normal weight for their age, and Panel C limits the sample to adolescents whose reported heights and weights imply that they are classified as overweight or obese for their age. It is worth restating that BMI-for-age cutoffs vary at the age-in-months level. As such, relatively younger students who are normal weight *for their age* might still weigh less than the older peers within the same classroom to whom they are comparing themselves.[19]

Table 4 shows that relatively younger students whose reported heights and weights classify them as being thin are more likely to describe themselves as "too thin" and less likely to describe themselves as being "about the right size" than their same-age counterparts who are relatively older within their respective classrooms (Panel A), suggesting that these students are more acutely aware of their BMI status. However, we find that relatively younger students whose reported heights and weights classify them as being normal weight for their age are less likely to feel that they are the correct size (Panel B). Instead, they are more likely to describe themselves as being "too thin."

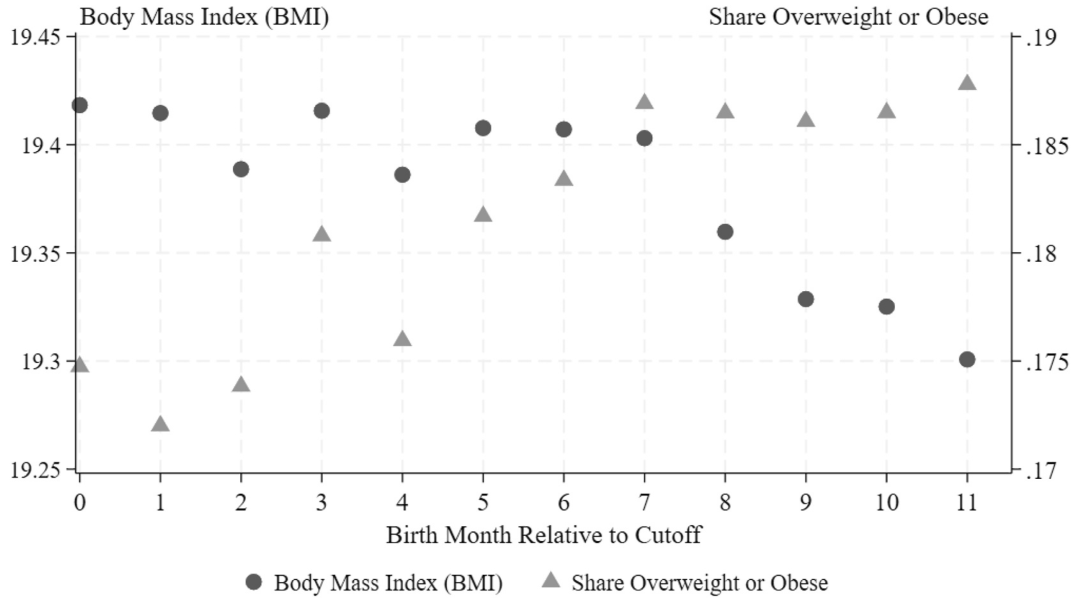


FIGURE 6 | Descriptive trends showing that adolescents born further from the school entry cutoff month have lower BMIs but are more likely to be classified as overweight or obese for their ages. *Source:* Health behaviour in school-aged children, 2002–2018. The figure plots the average body mass index (BMI) based on the students' birth month relative to the school entry cutoff. BMI is calculated based on reported height and weight and is denoted by the dark gray circles corresponding to the left axis. The figure also plots the share of students whose BMI leads them to be classified as overweight or obese using their sex-specific BMI-for-age thresholds. These shares are denoted by the lighter gray triangles corresponding to the right axis.

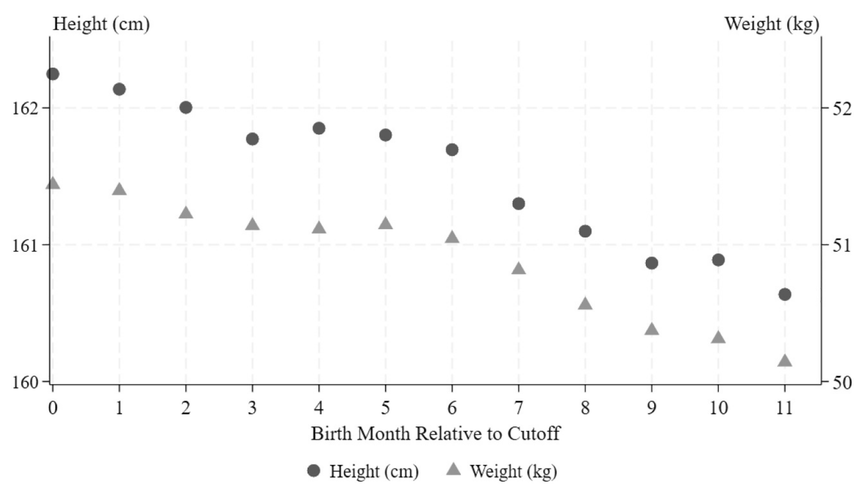


FIGURE 7 | Descriptive trends showing that adolescents born further from the school entry cutoff month are shorter and weigh less. *Source:* Health Behaviour in school-aged children, 2002–2018. The figure plots the average height (in centimeters) and weight (in kilograms) of students based on their birth month relative to the school entry cutoff. The dark gray circles correspond to the height values on the left axis. The lighter gray triangles correspond to the weight values on the right axis. The summary statistics utilize the sample weights.

Specifically, we find that a one standard deviation reduction in relative age is associated with a 1.6% point increase in the likelihood that normal weight adolescents describe themselves as "too thin"—a 10% increase relative to the sample mean. These results suggest that the misperception we previously documented is being driven by relatively younger students whose reported heights and weights are consistent with being considered normal weight for their younger age instead describing themselves as "too thin" relative to their older and larger peers. Finally, we do not detect any evidence of a statistically significant relationship between relative age and how overweight and obese students describe their bodies (Panel C).

In Table 5, we explore whether the relationship between relative age and how adolescents describe their bodies varies by both BMI status and sex. We find that relatively younger boys who are classified as thin for their age are particularly aware of their BMI status. While a one standard deviation reduction in relative age is associated with a 4.8% point increase in the likelihood that thin adolescent girls describe themselves as "too thin" (Panel A column 1), we document a 11.6% point increase in the likelihood that thin adolescent boys describe themselves as "too thin" (Panel A column 4). In contrast, the sex-specific difference is more muted for normal weight adolescents. Among this BMI group, we find that a one standard deviation reduction in relative age is associated with a 1.3% point increase in the likelihood that adolescent girls describe themselves as "too thin" (Panel B column 1) and a 1.2% point reduction in the likelihood that they describe themselves as being "about the right size" (Panel B column 2). Similarly, we find that a one standard deviation reduction in relative age is associated with a 1.8% point increase in the likelihood that normal weight adolescent boys describe themselves as "too thin" (Panel B column 4) and a 1.6% point reduction in the likelihood that they describe themselves as being "about the right size"

TABLE 6 | Relatively younger students are more likely to be overweight or obese than their same-age counterparts who are relatively older within their classrooms.

	(1)	(2)	(3)	(4)	(5)
		WHO BMI category			
Outcome →	**BMI**	**Thin**	**Normal weight**	**Overweight**	**Obese**
Panel A: Sample is all adolescents					
1 SD ↓ relative age	0.135***	−0.003***	−0.009***	0.012***	0.005***
	(0.021)	(0.001)	(0.003)	(0.002)	(0.001)
F-statistic	4989.43	4989.43	4989.43	4989.43	4989.43
Standard deviation	19.389	0.047	0.772	0.181	0.040
Mean	3.407	0.211	0.419	0.385	0.196
Observations	476,401	476,401	476,401	476,401	476,401
Panel B: Sample is adolescent girls					
1 SD ↓ relative age	0.104***	−0.007***	−0.001	0.008***	0.003**
	(0.026)	(0.002)	(0.003)	(0.003)	(0.001)
F-statistic	3972.29	3972.29	3972.29	3972.29	3972.29
Standard deviation	19.198	0.049	0.815	0.136	0.025
Mean	3.309	0.216	0.388	0.343	0.025
Observations	242,456	242,456	242,456	242,456	242,456
Panel C: Sample is adolescent boys					
1 SD ↓ relative age	0.168***	−0.000	−0.018***	0.018***	0.007***
	(0.033)	(0.002)	(0.004)	(0.004)	(0.002)
F-statistic	3018.47	3018.47	3018.47	3018.47	3018.47
Standard deviation	19.587	0.044	0.739	0.227	0.055
Mean	3.494	0.206	0.445	0.419	0.229
Observations	233,945	233,945	233,945	233,945	233,945

Note: The dependent variables are calculated from the WHO BMI category implied by each adolescent's reported height and weight. The dependent variable in column 1 is the adolescent's BMI. The dependent variable in column 2 is an indicator for whether the adolescent is classified as "thin," in column 3 for whether the adolescent is classified as "normal weight," in column 4 for whether the adolescent is classified as "overweight," and in column 5 for whether the adolescent is classified as "obese." The estimates are obtained using a two-stage least squares strategy shown in Equation (3) where birth month relative to the school entry cutoff is an instrument for relative age and the average age of comparable classroom peers is used as an instrument for absolute age. Panel A is all adolescents, Panel B limits the sample to adolescent girls, and Panel C limits the sample to adolescent boys. The estimates utilize the sample weights. Standard errors, shown in parentheses, are clustered at the classroom level.
Source: Health behaviour in school-aged children, 2002–2018.
*$p < 0.10$.
**$p < 0.05$.
***$p < 0.01$.

(Panel B column 5). Again, we find no clear evidence of a relationship between relative age and body descriptions for overweight and obese adolescents (Panel C).

We now test whether relative age is related to changes in reported BMI. The descriptive statistics in Figure 6 reveal an interesting pattern—students born further from the school entry cutoff month report heights and weights that imply lower BMIs than those born closer to the cutoff month (dark gray circles). However, these students are also *more likely* to be classified as overweight or obese for their age (light gray triangles). This suggests that while these students born further from the cutoff weigh less in an absolute sense, it is not sufficiently less to keep them within the recommended range of their age-specific BMI recommendation. Figure 7 shows that students born further from the school entry cutoff month report being shorter (dark gray circles) and weighing less (light gray triangles).

We report estimates of the relationship between relative age and BMI calculated from reported height and weight in Table 6. The dependent variable in column 1 is the student's BMI implied by her reported height and weight. Meanwhile, the dependent variables in columns 2–5 are indicators denoting whether the student would be classified as "thin," "normal weight," "overweight," or "obese" using the 2007 World Health Organization's BMI-for-age (in months) thresholds for girls and boys. Panel A examines all adolescents, Panel B examines adolescent girls, and Panel C examines adolescent boys.

We find that a one standard deviation reduction in relative age is associated with a 0.14-unit (0.7%) increase in reported BMI (Panel A column 1).[20] While seemingly modest, the average difference between the recommended BMI value and a BMI classifying a given adolescent as overweight in our data is 2.8 units. Indeed, relatively younger students are less likely to be classified as "thin" (Panel A column 2) and "normal weight" (Panel A column 3) for their age than their same-age counterparts who are relatively older within their classrooms. Instead, we find that a one standard deviation reduction in relative age is associated with a 1.2% point (6.6%) increase in the likelihood that adolescents are classified as overweight (Panel A column 4) and a 0.5% point (12.5%) increase in the likelihood they are classified as obese (Panel A column 5). These results are consistent with M. P. Anderson et al. (2011) who found suggestive evidence that students born immediately prior to the cutoff date were more likely to be classified as overweight. Interestingly, we find that the relationships are less pronounced for adolescent girls (Panel B) in both absolute magnitude and as a percent change relative to the mean than for adolescent boys (Panel C).

What might explain this pattern of results? On the one hand, relatively younger students may adopt the weight-related behaviors of their relatively older peers in an effort to match their physiques. However, because the WHO BMI thresholds are based vary at the age-in-months level, relatively younger students weighing the same as their relatively older peers may be classified as overweight. Indeed, Figure 8 shows that a one standard deviation reduction in relative age is associated with a statistically significant 0.9% increase in bodyweight. In contrast, the relationship between relative age and height is small, precisely estimated, and statistically insignificant. Indeed, recognizing that adolescents may target their bodies to those of their peers to their increasingly overweight and obese peers, many schools now require adolescents undergo regular BMI assessments to inform them about their overweight status (Almond et al. 2016; Madsen et al. 2021; Churchill 2024). Yet another possibility is that relative

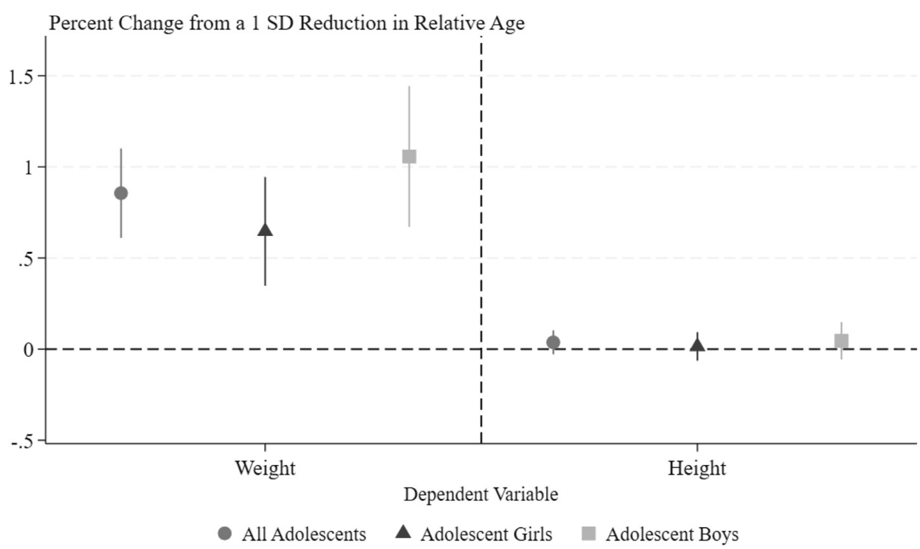


FIGURE 8 | Relatively younger students report weighing more than their same-age counterparts who are relatively older within their classrooms. *Source*: Health behaviour in school-aged children, 2002–2018. The figures plot the percentage change relative to the sample mean associated with a one standard deviation decrease in relative age. The dependent variable is listed on the horizontal axis, including the student's weight (in kilograms) and the student's height (in centimeters). The gray circles denote estimates for the full sample, the dark gray triangles denote estimates for adolescent girls, and the light gray squares denote estimates for adolescent boys. The vertical lines denote the 95% confidence intervals. The estimates are obtained using a two-stage least squares strategy in Equation (3) where birth month relative to the school entry cutoff is an instrument for relative age and the average age of comparable classroom peers is used as an instrument for absolute age. The corresponding estimates are reported in Appendix Table 12. The estimates utilize the sample weights. Standard errors are clustered at the classroom level.

younger students may systematically overreport their bodyweight to be consistent with their relatively older peers. Because the HBSC data do not contain a validated measure of BMI, we are unable to determine whether these results reflect changes in students' BMIs or their views on the optimal weights.

4.3 | Effects on Weight Management Behaviors

In the prior sections, we showed that students who are younger within their classrooms describe themselves as lighter than the clinically relevant WHO BMI category implied by their reported heights and weights. Yet we also found that these students are more likely to be classified as overweight or obese. Given these changes in body misperception and weight outcomes, in this section we explore the relationship between relative age and a variety of weight-related health behaviors, including dieting, consumption of healthy foods, and physical activity.[21]

Table 7 tests whether relative age influences adolescents' dieting behaviors. While we do not find any evidence that relative age is associated with a change in whether adolescents report being on a diet (Panel A column 1), we do detect a shift in the views of adolescents who report not being on a diet. Students who are one standard deviation younger in relative terms than their classroom peers are 1.3% points (2.6%) less likely to say that they are not on a diet and have no reason to be on one (Panel A column 2) and 0.9% points (10%) more likely to say that they are not dieting because they need to gain weight (Panel A column 3). This is consistent with evidence that these relatively younger students are more likely to describe themselves as "too thin." While we detect increases for both adolescent girls and adolescent boys, the relationship is more pronounced for adolescent boys. We find that a one standard deviation reduction in relative age is associated with a 0.5% point (6.8%) increase in the likelihood that adolescent girls report that they believe that they need to gain weight (Panel B column 3) and a 1.2% point (11%)

TABLE 7 | Relatively younger students are more likely to want to gain weight than their same-age counterparts who are relatively older within their classrooms.

	(1)	(2)	(3)	(4)
		Not on a diet…		
Outcome →	Currently on a diet	My weight is fine	Because I need to gain weight	But I should lose weight
Panel A: Sample is all adolescents				
1 SD ↓ relative age	0.001	−0.013***	0.009***	0.003
	(0.002)	(0.003)	(0.002)	(0.003)
F-statistic	4600.99	4600.99	4600.99	4600.99
Mean	0.145	0.561	0.091	0.202
Standard deviation	0.352	0.496	0.288	0.402
Observations	454,163	454,163	454,163	454,163
Panel B: Sample is adolescent girls				
1 SD ↓ relative age	0.002	−0.008**	0.005**	0.001
	(0.003)	(0.004)	(0.002)	(0.004)
F-statistic	3886.43	3886.43	3886.43	3886.43
Mean	0.187	0.494	0.074	0.245
Standard deviation	0.390	0.500	0.261	0.430
Observations	232,845	232,845	232,845	232,845
Panel C: Sample is adolescent boys				
1 SD ↓ relative age	0.001	−0.019***	0.012***	0.005
	(0.003)	(0.005)	(0.003)	(0.003)
F-statistic	2856.00	2856.00	2856.00	2856.00
Mean	0.102	0.632	0.109	0.157
Standard deviation	0.302	0.482	0.312	0.364
Observations	221,318	221,318	221,318	221,318

Note: The dependent variable in column 1 is an indicator for whether the student reported currently being on a diet, in column 2 for whether the student reported not having any reason to diet, in column 3 for whether the student reported that while s/he isn't on a diet s/he should diet to gain weight, and in column 4 for whether the student reported that while s/he isn't on a diet s/he should diet to lose weight. The estimates are obtained using a two-stage least squares strategy shown in Equation (3) where birth month relative to the school entry cutoff is an instrument for relative age and the average age of comparable classroom peers is used as an instrument for absolute age. Panel A is all adolescents, Panel B limits the sample to adolescent girls, and Panel C limits the sample to adolescent boys. The estimates utilize the sample weights. Standard errors, shown in parentheses, are clustered at the classroom level.
Source: Health behaviour in school-aged children, 2002–2018.
*$p < 0.10$.
**$p < 0.05$.
***$p < 0.01$.

increase for adolescent boys (Panel C column 3). This pattern is consistent with an interdisciplinary literature showing that adolescent boys in particular are concerned about being perceived as smaller than their peers (Ricciardelli et al. 2000; Bearman et al. 2006; Wiklund et al. 2019).[22]

Relatively younger adolescents desiring to gain weight is consistent with our prior results that these adolescents are also more likely to perceive themselves as lighter than the clinically relevant WHO BMI category suggested by their reported heights and weights. To more precisely identify the students driving the increase, in Table 8 we report results when restricting the sample based on self-described body type and the clinically relevant WHO BMI category implied by the reported heights and weights. We generally find that relatively younger adolescents who are classified as thin for their age are more likely to report that they need to gain weight, regardless of how they describe their bodies (Panel A). However, the sample sizes for these groups are small and the relationships imprecisely estimated. We also find that relatively younger normal weight adolescents who describe themselves as "too thin" are more likely to report that they need to gain weight (Panel B column 1). We do not detect any changes among normal weight adolescents who describe themselves as being "about the right size" (Panel B column 2) or "too fat" (Panel B column 3). Finally, we do not detect any change for adolescents whose reported heights and weights imply that they are classified as overweight or obese (Panel C). Overall, Table 8 is consistent with relatively younger adolescents who incorrectly believe that they are too thin being those more likely to report a desire to gain weight.

Next, we test the relationship between relative age and caloric intake. The dependent variables in Table 9 are the number of

TABLE 8 | Relatively younger students who are classified as normal weight but describe themselves as too thin are more likely to report a need to gain weight than their same-age counterparts who are relatively older within their classrooms.

	(1)	(2)	(3)
Outcome →	**Not on a diet because I need to gain weight**		
Sample →	**Self-described too thin**	**Self-described about the right size**	**Self-described too fat**
Panel A: Sample is thin adolescents			
1 SD ↓ relative age	0.030	0.044**	0.059
	(0.026)	(0.019)	(0.045)
F-statistic	172.44	127.96	15.47
Mean	0.558	0.100	0.081
Standard deviation	0.497	0.300	0.273
Observations	8043	7977	1097
Panel B: Sample is normal weight adolescents			
1 SD ↓ relative age	0.024**	0.003	−0.002
	(0.011)	(0.002)	(0.002)
F-statistic	875.02	2840.45	1983.28
Mean	0.448	0.045	0.013
Standard deviation	0.497	0.207	0.111
Observations	44,674	180,322	64,117
Panel C: Sample is overweight and obese adolescents			
1 SD ↓ relative age	−0.032	−0.001	−0.000
	(0.074)	(0.004)	(0.000)
F-statistic	19.78	504.63	1147.04
Mean	0.236	0.021	0.009
Standard deviation	0.425	0.142	0.095
Observations	1492	21,472	42,178

Note: The dependent variable is an indicator for whether the student reported that while s/he isn't on a diet s/he should diet to gain weight. The sample is stratified by the WHO BMI category implied by the students' reported heights and weights. Panel A examines thin adolescents, Panel B examines normal weight adolescents, and Panel C examines overweight and obese adolescents. Column 1 limits the sample to adolescents who described themselves as being "much too thin" or "too thin." Column 2 limits the sample to adolescents who described themselves as being "about the right size." Column 3 limits the sample to adolescents who described themselves as being "too fat" or "much too fat." The estimates are obtained using a two-stage least squares strategy shown in Equation (3) where birth month relative to the school entry cutoff is an instrument for relative age and the average age of comparable classroom peers is used as an instrument for absolute age. The estimates utilize the sample weights. Standard errors, shown in parentheses, are clustered at the classroom level.
Source: Health behaviour in school-aged children, 2002–2018.
*$p < 0.10$.
**$p < 0.05$.
***$p < 0.01$.

times per week the student reports consuming fruits, vegetables, sweets, and soda. We find that students who are one standard deviation younger in relative age report eating fruit 0.08 fewer times per week (Panel A column 1). These relatively younger students also report eating vegetables 0.05 fewer times per week (column 2). In addition to finding that relatively younger students eat fewer low-calorie items, we also find evidence that they consume more calorie-dense foods. We find that students who are one standard deviation younger in relative age report eating sweets 0.05 more times per week (column 3) and report drinking soda 0.8 more times per week (column 4). Next, we show that the increase in consumption of sweets is driven by relatively younger adolescent girls (Panel B), while the reduction in fruit and vegetable consumption is driven by relatively younger adolescent boys (Panel C).[23]

It is worth noting that the measure used in this table (i.e., the number of times eating a category of food) is an imperfect proxy of caloric intake, given that students might consume multiple servings of the items in a single sitting. However, if we are willing to assume that students consume one serving each time they eat the item, we can use the estimates from Table 9 to estimate calorie differences throughout the year. Assuming that dessert has 300 calories per serving and soda has 150 calories per serving, our estimates imply that students who are one standard deviation younger in relative age will consume 26.25 more calories per week—a 1365 calorie increase over the course of the year. There are 7700 calories in a kilogram, so our estimates imply a 0.18 kg increase in bodyweight attributable to these relatively younger students' increased consumption of sweets and sodas. We previously estimated that a one standard deviation reduction in relative age results in a 0.44 kg increase in bodyweight (see Figure 8 and Appendix Table 12, suggesting that changes in dieting behaviors attributable to relative age cannot fully explain the estimated increase in bodyweight.

Of course, in addition to monitoring and altering their caloric intake, students can influence their body weight by changing their caloric expenditure. However, the predicted direction is not clear. We have shown that relatively younger students are

TABLE 9 | Relatively younger students consume fewer low-calorie items and more calorie-dense items than their same-age counterparts who are relatively older within their classrooms.

Times per week eating →	(1) Fruits	(2) Vegetables	(3) Sweets	(4) Soda
Panel A: Sample is all adolescents				
1 SD ↓ relative age	−0.081***	−0.050***	0.050***	0.075***
	(0.018)	(0.017)	(0.017)	(0.019)
F-statistic	5940.67	5940.67	5940.67	5940.67
Mean	4.940	4.759	3.942	3.239
Standard deviation	3.188	3.079	3.086	3.237
Observations	568,220	568,220	568,220	568,220
Panel B: Sample is adolescent girls				
1 SD ↓ relative age	−0.037	−0.024	0.065***	0.056**
	(0.024)	(0.023)	(0.023)	(0.024)
F-statistic	4876.55	4876.55	4876.55	4876.55
Mean	5.191	5.002	3.999	2.898
Standard deviation	3.192	3.066	3.091	3.144
Observations	291,787	291,787	291,787	291,787
Panel C: Sample is adolescent boys				
1 SD ↓ relative age	−0.135***	−0.082***	0.033	0.095***
	(0.027)	(0.026)	(0.027)	(0.029)
F-statistic	3657.20	3657.20	3657.20	3657.20
Mean	4.676	4.503	3.882	3.598
Standard deviation	3.162	3.071	3.079	3.294
Observations	276,433	276,433	276,433	276,433

Note: The dependent variable in column 1 is the number of times per week the student reports eating fruits, in column 2 the number of times per week the student reports eating vegetables, in column 3 the number of times per week the student reports eating sweets, and in column 4 the number of times per week the student reports drinking sodas. The estimates are obtained using a two-stage least squares strategy from Equation (3) where birth month relative to the school entry cutoff is an instrument for relative age and the average age of comparable classroom peers is used as an instrument for absolute age. Panel A is all adolescents, Panel B limits the sample to adolescent girls, and Panel C limits the sample to adolescent boys. The estimates utilize the sample weights. Standard errors, shown in parentheses, are clustered at the classroom level.
Source: Health behaviour in school-aged children, 2002–2018.
*$p < 0.01$.
**$p < 0.05$.
***$p < 0.01$.

more likely to describe themselves as "too thin" and report that they need to gain weight compared to their same-age counterparts who are relatively older within their respective classrooms. These students may choose to forgo physical activity out of a concern that it will lower their weight, and prior work has shown that relatively younger students are at a disadvantage for sports participation (Allen and Barnsley 1993; Dhuey and Lipscomb 2008; Fumarco and Gabriel 2020). Yet it is also possible that relatively younger students may increase their level of physical activity to build muscle mass.

In Table 10, we find that relatively younger students are less likely to be physically active than their same-age counterparts who are relatively older within their respective classrooms. We find that students who are one standard deviation younger in relative age report being active on 0.12 fewer days—a 3.0% reduction relative to the sample mean (Panel A column 1). Likewise, we find these relatively younger students report 4.5% fewer instances of exercising outside of school (Panel A column 2) and report spending 3.9% fewer hours exercising outside of school (Panel A column 3). The results are smaller in magnitude and as a percentage change relative to the sample means for adolescent girls (Panel B) relative to adolescent boys (Panel C).[24]

5 | Discussion and Conclusion

There is a growing concern that negative social comparisons are adversely affecting adolescent mental health (Vincent and McCabe 2000; Webb and Zimmer-Gembeck 2014; Murthy 2024). At the same time, policymakers and public health advocates worry that the rising childhood obesity rate has made it difficult

TABLE 10 | Relatively younger students are less physically active than their same-age counterparts who are relatively older within their classrooms.

Outcome →	(1) Number of days last week physically active for ≥ 60 minutes	(2) Number of times exercising outside of school	(3) Number of hours exercising outside of school
Panel A: Sample is all adolescents			
1 SD ↓ relative age	−0.120***	−0.151***	−0.096***
	(0.011)	(0.014)	(0.014)
F-statistic	5913.62	5706.10	4589.07
Mean	4.088	3.321	2.520
Standard deviation	2.045	2.330	2.223
Observations	560,575	465,717	358,910
Panel B: Sample is adolescent girls			
1 SD ↓ relative age	−0.090***	−0.117***	−0.072***
	(0.015)	(0.017)	(0.017)
F-statistic	4832.99	4590.17	3819.35
Mean	3.812	2.912	2.182
Standard deviation	2.007	2.249	2.066
Observations	287,282	238,968	184,461
Panel C: Sample is adolescent boys			
1 SD ↓ relative age	−0.160***	−0.196***	−0.129***
	(0.018)	(0.022)	(0.023)
F-statistic	3652.51	3398.054	2710.34
Mean	4.377	3.750	2.875
Standard deviation	2.045	2.336	2.234
Observations	273,293	226,749	174,449

Note: The dependent variable in column 1 is the number of days the student reports being physically active for at least 60 min. The dependent variable in column 2 is the number of times the student reports exercising outside of school where s/he gets out of breath or sweats. The dependent variable in column 3 is the number of hours a week that the student reports exercising where s/he gets out of breath or sweats. The estimates are obtained using a two-stage least squares strategy from Equation (3) where birth month relative to the school entry cutoff is an instrument for relative age and the average age of comparable classroom peers is used as an instrument for absolute age. Panel A is all adolescents, Panel B limits the sample to adolescent girls, and Panel C limits the sample to adolescent boys. The estimates utilize the sample weights. Standard errors, shown in parentheses, are clustered at the classroom level.
Source: Health behaviour in school-aged children, 2002–2018.
*$p < 0.10$.
**$p < 0.05$.
***$p < 0.01$.

for adolescents and parents to recognize when children have excess body weight (Hernandez et al. 2010; Almond et al. 2016; Madsen et al. 2021; Churchill 2024). Despite both concerns, endogeneity in media consumption and friend formation make it empirically difficult to identify how social comparisons shape adolescent body image and weight-related behaviors. In this study, we adopt an instrumental variables approach leveraging variation in relative age within the classroom generated by school entry cutoff months and data drawn from the 2002–2018 waves of the Health Behaviour in School-Aged Children (HBSC) study. The idea behind this strategy is that students born immediately following the school entry cutoff will be relatively older within their classroom (i.e., they will have relatively younger and presumably smaller peers) compared to an identically aged student born immediately prior to the cutoff.

We show that relatively younger students are more likely to describe themselves as lighter than indicated by their BMIs. This change in body misperception is driven by changes in both how relatively older students describe their bodies and in their underlying BMIs. Interestingly, we find that relatively younger students (i.e., those with older peers) are both (i) more likely to describe themselves as being too thin and (ii) more likely to be classified as overweight or obese based on their age-specific BMI thresholds. We then show that these relatively younger students who—despite reporting heights and weights that would categorize them as normal weight—describe themselves as "too thin" are more likely to report a belief that they should gain weight. Relatedly, we show that relatively younger students eat more calorie-dense food and report lower levels of physical activity. Overall, our results suggest that relatively younger students base their weight-related expectations and behaviors on the behaviors and body types of their older peers.

This study is subject to some limitations. For one, as is common in this literature, our data on body image, weight-related behaviors (e.g., dieting, physical activity), and weight outcomes are self-reported. While self-reported data are perhaps most appropriate when examining changes in body image, they provide us with relatively coarse measures of physical activity and calorie intake. Moreover, prior evidence indicates that self-reported anthropometric measures can suffer from non-classical measurement error. While there is no reason to believe that the propensity to under or overreport these measures should be correlated with relative age—particularly when we are exploiting school entry cutoff months throughout the year in a variety of countries—identifying ways to more accurately capture changes in physical activity and calorie intake remains an important area for future research. Also, because our sample is comprised entirely of adolescents, we can only speculate as to whether these social comparisons similarly influence weight-related behaviors among adults. Despite these limitations, this study provides the most comprehensive evidence on the role of peer social comparisons in driving weight-related health behaviors and outcomes.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Endnotes

[1] 20 countries have a January cutoff, one country has a March cutoff, one country has an April cutoff, two countries have a July cutoff, seven countries have a September cutoff, and two countries have an October cutoff.

[2] In line with these findings, Black et al. (2011) found that girls who started school when they were older were less likely to experience teen pregnancy.

[3] In our results section, we will show that our results are consistent across each survey wave. Because very few adolescents had cell phones and social media in 2002, these patterns suggest that our findings are not attributable to changes in technology utilization.

[4] Appendix Figure 1 plots the distribution of the number of schools sampled per country-year (Panel A) and the number of classrooms sampled per country-year-school (Panel B).

[5] The HBSC surveys do not include information on whether students remain in the same classroom over time or change classrooms throughout the day. We utilize information based on the classroom where the student completed the survey. However, even if students switch classrooms throughout the day, it is important to note that students who are relatively younger within the classroom in which they completed the survey would likely be relatively younger their subsequent classrooms.

[6] Because this process requires classroom-specific information, we exclude observations without a classroom identifier. We also follow prior work and exclude classes in the top and bottom 5% of the class size distribution, given concerns that these codes are not identifying unique classrooms. Our remaining classes range from 8 to 32 students, consistent with Fumarco and Baert (2019).

[7] For Figure 1, we bin the endpoints at −12 and 12. However, we use the non-binned values throughout our analyses.

[8] We report additional summary statistics in Appendix Table 1.

[9] The WHO provides sex-specific BMI-for-age (in months) thresholds. Adolescents whose BMI is more than 3 standard deviations below the cutoff are considered "severely thin," those whose BMI is more than 2 standard deviations below the cutoff are considered "thin," those whose BMI is more than 1 standard deviation above the cutoff are considered "overweight," and those whose BMI is more than 2 standard deviations above the cutoff are considered "obese." This definition implies than anyone who is "severely thin" is also "thin" and anyone who is "obese" is also "overweight." When calculating the weight perception variable, we allow these categories to be mutually exclusive.

[10] HBSC guidelines suggest that socioeconomic status be measured by adding the answers to four questions: (i) whether the respondent's family owns zero, one, or more than one car; (ii) whether the respondent sleeps in her own bedroom; (iii) whether the respondent has traveled for holidays in the prior 12 months never, once, or more than once; and (iv) whether the respondent's family owns zero, one, or more than one computer. The resulting sum is then divided into three levels (i.e., low, medium, and high socioeconomic status).

[11] Appendix Table 2 lists the country-specific school entry cutoff dates.

[12] Appendix Table 3 shows that our instrumental variables for relative age are unrelated to meaningful changes in the right-hand side demographic characteristics. The one unsurprising exception is that students born further from the school entry cutoff month are consistently younger in absolute age.

[13] We report estimates for additional covariates in Appendix Table 4. We show that while the relationship between relative age and body

perception did not meaningfully vary by sex, adolescent girls are more likely to describe their bodies as heavier than the clinically relevant WHO BMI category implied by their reported heights and weights. We also show that adolescent girls are more likely to describe themselves as heavier than their BMI category as they age while adolescent boys increasingly describe themselves as lighter than their BMI category as they age. Meanwhile, Appendix Table 5 shows that the results are robust to excluding observations at the extreme ends of the distribution in terms of height (Panel A), weight (Panel B), and relative age (Panel C).

[14] Appendix Figures 2 and 3 reveal changes across Europe and for all age groups, though the estimates from Eastern Europe are less precisely estimated and the percent changes are largest for the younger students.

[15] We explored whether relatively younger students may be more likely to describe themselves as lighter than indicated by the clinically relevant WHO BMI category implied by their reported heights and weights because they experience bullying at school. Appendix Figure 4 and Appendix Table 8 both support the fact that relatively younger students are more likely to be bullied (column 1). However, relatively younger students are more likely to describe themselves as lighter than their BMI category, regardless of whether they do or do not report being bullied at school (columns 2 and 3).

[16] Appendix Table 9 explores whether the relationship between relative age and body image varies based on the average classroom BMI. After calculating the average classroom BMI, we determined the distribution for classrooms with 11-year-old adolescents, the distribution for classrooms with 13-year-old adolescents, and the distribution for classrooms with 15-year-old adolescents. We then separately examined the relationship between relative age and body image for those in the first quartile of the relevant distribution (column 1), the middle two quartiles (column 2), or the top quartile (column 3). We find that relatively younger adolescents described themselves as lighter than the clinically relevant WHO BMI category implied by their heights and weights, regardless of their average classroom BMI (Panel A). However, we find that the relationship was most pronounced for adolescent girls in classrooms with relatively higher BMIs (Panel B) but for adolescent boys in classrooms with relatively lower BMIs (Panel C).

[17] These findings are also consistent with public health and psychology literature documenting rates of body dissatisfaction among adolescent boys (Karazsia et al. 2017; Baker et al. 2019; Gonzaga et al. 2023).

[18] Appendix Table 10 explores how the relationship between relative age and body perception varied by age for all adolescents (Panel A), adolescent girls (Panel B), and adolescent boys (Panel C). We find that 11-year-old adolescent girls who are relatively younger are more likely to describe themselves as lighter than the clinically relevant WHO BMI category implied by their reported heights and weights than their same-age counterparts who are relatively younger within their respective classrooms. However, this relationship is attenuated as girls age. While we similarly find that relatively younger boys are more likely to describe themselves as lighter than the clinically relevant WHO BMI category implied by their reported heights and weights, we also detect a similar pattern for 13- and 15-year-old boys.

[19] For example, imagine two girls within the same classroom who have a BMI of 15.2. The first girl is 13.75 years old while the second is 13.0 years old. Despite having the same BMI, the relatively older girl is classified as thin, while the relatively younger girl is classified as normal weight.

[20] Appendix Table 11 shows that this result is robust to dropping students born near the school entry cutoff. Appendix Figure 5 shows similar BMI changes in BMI for all European regions (Panel A) and for 11-, 13-, and 15-year-old adolescents (Panel B).

[21] It is worth noting that these measures of dieting, food consumption, and physical activity are not subsequently validated. It is possible that relative age within the classroom makes students differentially likely to misreport their weight management activities, resulting in non-classical measurement error.

[22] We do not detect meaningful differences across European regions (Appendix Figure 6) or age groups (Appendix Figure 7).

[23] Appendix Figure 8 shows similar changes in dietary intake across European regions. Appendix Figure 9 presents mixed evidence for the relationship between relative age and dietary intake for each age group. We find similar changes in fruit consumption (Panel A). However, while we find that relatively younger 11-year-olds are more likely to consume sweets and sodas, this relationship appears to flip as students age (Panels C and D).

[24] Appendix Figure 10 shows similar changes across European regions. Appendix Figure 11 suggests that the increase in the number of days active for more than 60 min was larger for 13- and 15-year-olds than 11-year-olds (Panel A), though there were similar changes in the number of times all age groups reported exercising outside of school (Panel B).

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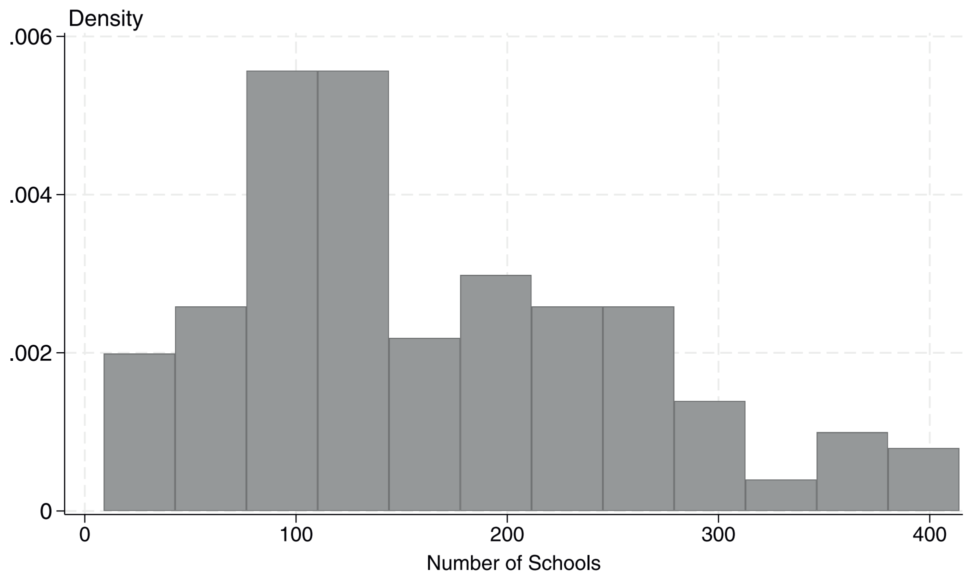
Appendix A



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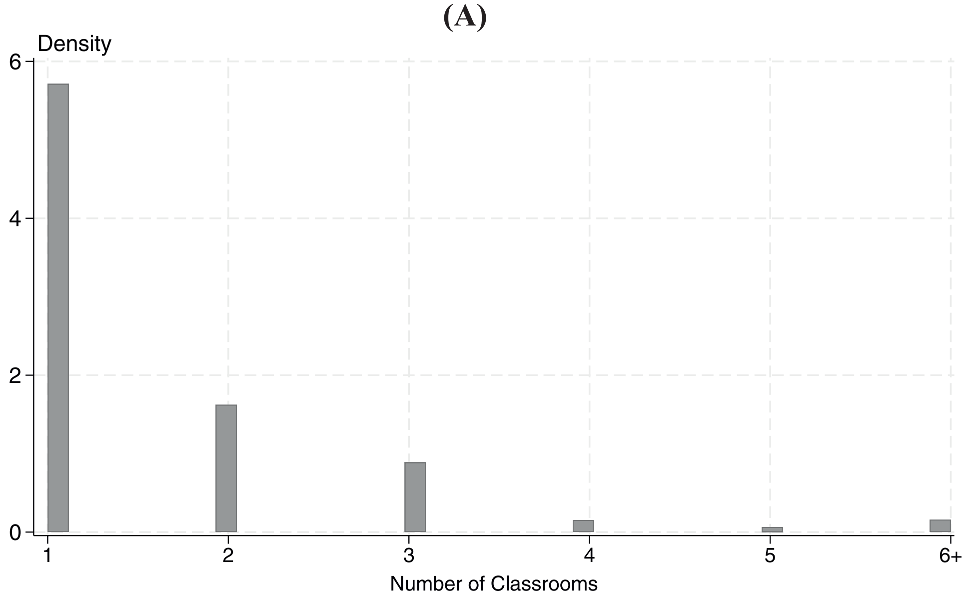


(B)

FIGURE A1 | Number of schools and classrooms in the HBSC Data. *Source:* Health behaviour in school-aged children, 2002–2018. Panel A plot the number of schools per country-year. Panel B plots the number of classrooms per county-year-school.

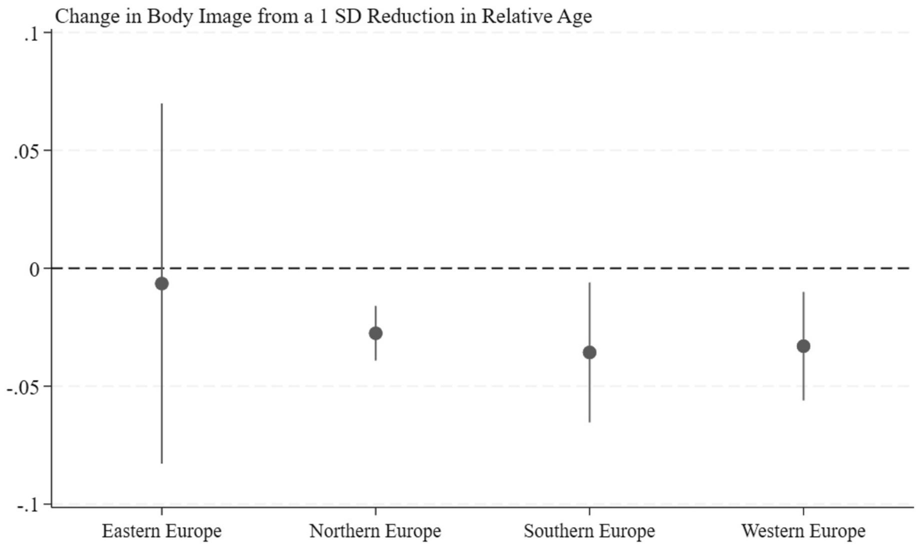


FIGURE A2 | Relationship between relative age and body image, by region of europe. *Source:* Health behaviour in school-aged children, 2002–2018. The dependent variable is the student's self-perception relative to his or her BMI. This value is constructed by taking the difference between a variable denoting how the student described his or her body and a variable denoting the student's BMI status corresponding to his or her reported height and weight. The former variable takes on the value of 1 if the student describes his or her body as "much too thin," 2 if the student describes his or her body as "a bit too thin," 3 if the student describes his or her body as "about the right size," 4 if the student describes his or her body as "a bit too fat," and 5 if the student describes his or her body as "much too fat." The latter variable takes on the value of 1 if the student is classified as "severely thin," 2 for those classified as "thin," 3 for those classified as "normal weight," 4 for those classified as "overweight," and 5 for those classified as "obese." Positive values indicate that the student described his or her body as heavier than indicated by the clinically relevant WHO BMI category implied by his or her reported height and weight. The estimates are obtained using a two-stage least squares strategy shown in Equation (3) where birth month relative to the school entry cutoff is an instrument for relative age and the average age of comparable classroom peers is used as an instrument for absolute age. For ease of interpretation, the graph reports the change associated with a one standard deviation reduction in relative age. Observations are limited to the region of Europe indicated on the horizontal axis. The circles plot the estimates, and the vertical lines denote the corresponding 95% confidence intervals. The estimates utilize the sample weights. Standard errors are clustered at the classroom level.

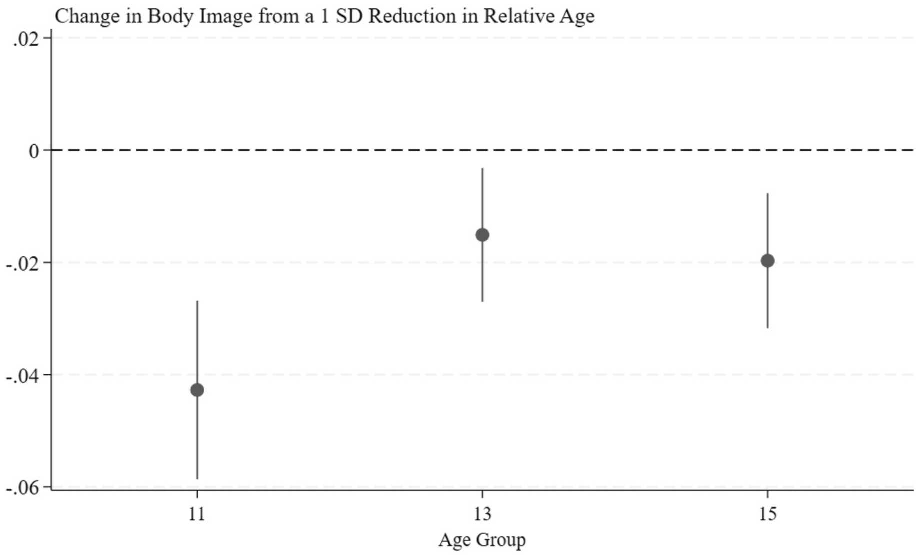


FIGURE A3 | Relationship between relative age and body image, by age group. *Source:* Health behaviour in school-aged children, 2002–2018. The dependent variable is the student's self-perception relative to his or her BMI. This value is constructed by taking the difference between a variable denoting how the student described his or her body and a variable denoting the student's BMI status corresponding to his or her reported height and weight. The former variable takes on the value of 1 if the student describes his or her body as "much too thin," 2 if the student describes his or her body as "a bit too thin," 3 if the student describes his or her body as "about the right size," 4 if the student describes his or her body as "a bit too fat," and 5 if the student describes his or her body as "much too fat." The latter variable takes on the value of 1 if the student is classified as "severely thin," 2 for those classified as "thin," 3 for those classified as "normal weight," 4 for those classified as "overweight," and 5 for those classified as "obese." Positive values indicate that the student described his or her body as heavier than indicated by the clinically relevant WHO BMI category implied by his or her reported height and weight. The estimates are obtained using a two-stage least squares strategy shown in Equation (3) where birth month relative to the school entry cutoff is an instrument for relative age and the average age of comparable classroom peers is used as an instrument for absolute age. For ease of interpretation, the graph reports the change associated with a one standard deviation reduction in relative age. Observations are limited to the absolute age group on the horizontal axis. The circles plot the estimates, and the vertical lines denote the corresponding 95% confidence intervals. The estimates utilize the sample weights. Standard errors are clustered at the classroom level.

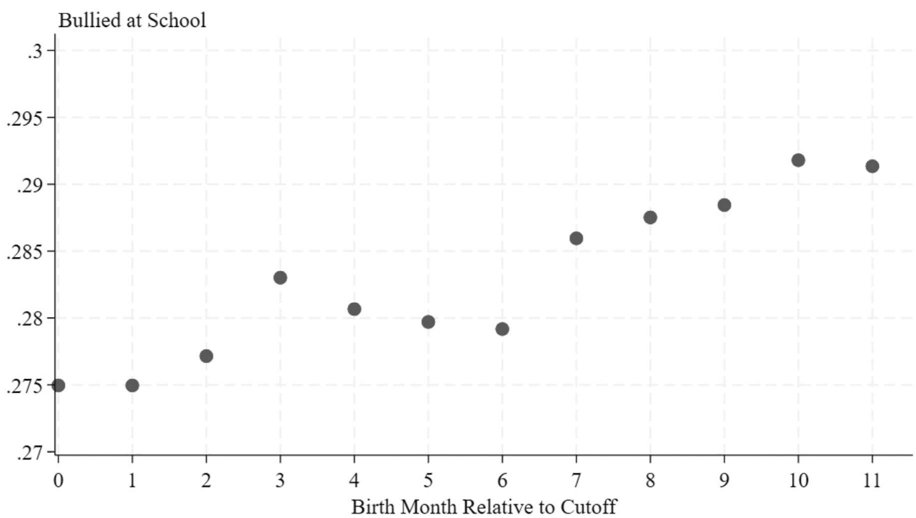
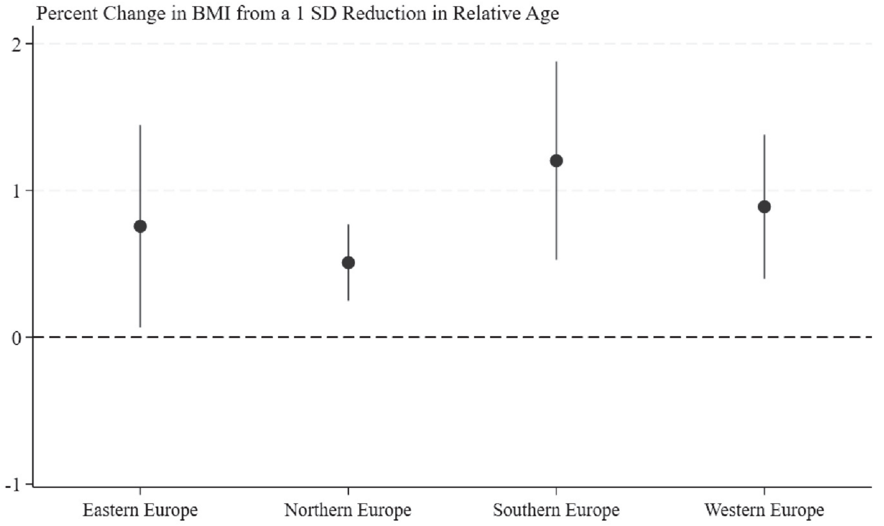


FIGURE A4 | Descriptive trends showing that adolescents born further from the school entry cutoff month are more likely to be victims of bullying. *Source:* Health behaviour in school-aged children, 2002–2018. The figure plots the share of students who report being bullied at school. The summary statistics utilize the sample weights. Standard errors are clustered at the classroom level.



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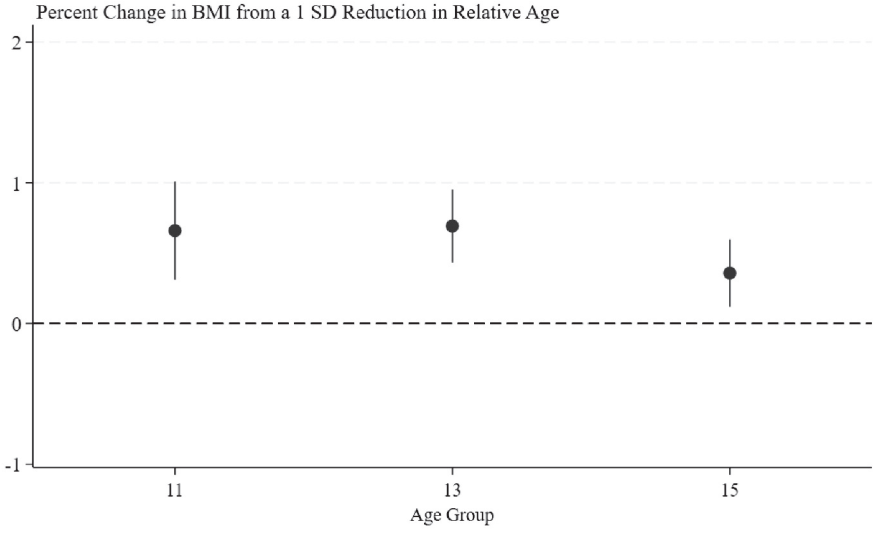


(B)

FIGURE A5 | Relationship between relative age and BMI, by region of Europe and Age. *Source:* Health behaviour in school-aged children, 2002–2018. The figures plot the percent change relative to the sample mean associated with a one standard deviation reduction in relative age. The dependent variable is the adolescent's body mass index calculated from his or her reported height and weight. In Panel A, observations are limited to the region of Europe indicated on the horizontal axis. In Panel B, observations are limited to the age category indicated on the horizontal axis. The circles plot the estimates, and the vertical lines denote the corresponding 95% confidence intervals. The estimates are obtained using a two-stage least squares strategy shown in Equation (3) where birth month relative to the school entry cutoff is an instrument for relative age and the average age of comparable classroom peers is used as an instrument for absolute age. The estimates utilize the sample weights. Standard errors are clustered at the classroom level.

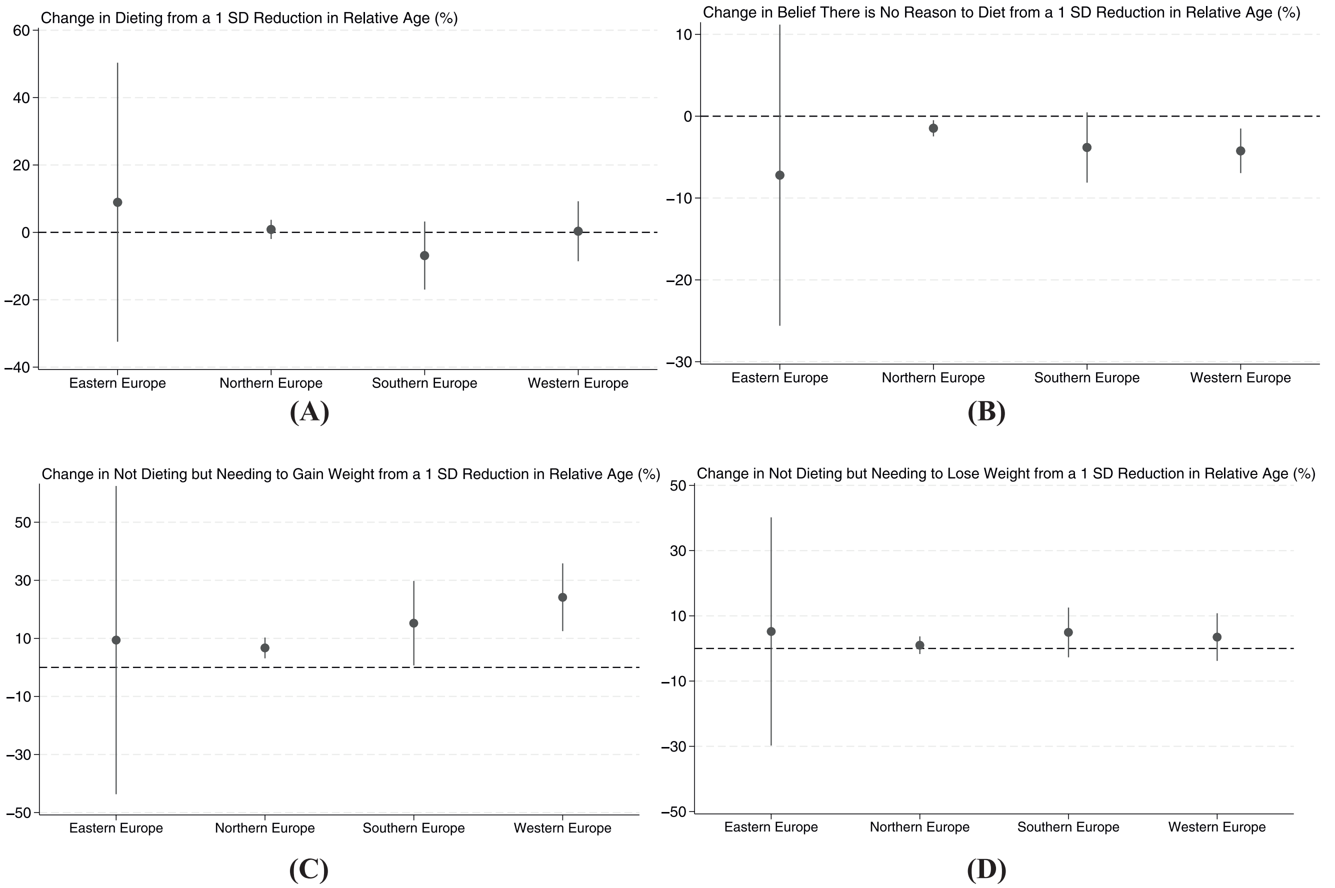
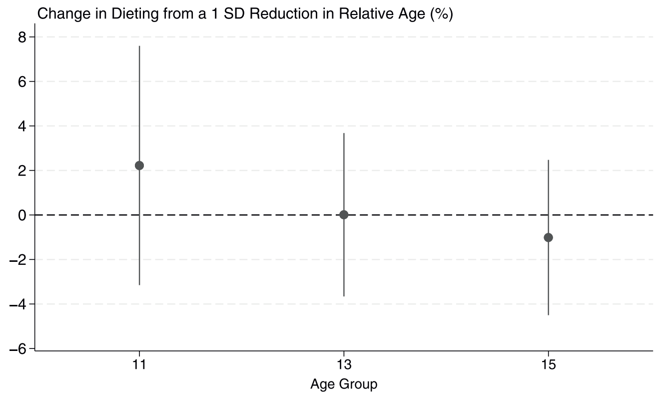


FIGURE A6 | Relationship between relative age and dieting behaviors, by region of Europe. *Source:* Health behaviour in school-aged children, 2002–2018. The figures plot the percentage change relative to the sample mean associated with a one standard deviation reduction in relative age. The dependent variable in Panel A is an indicator for whether the adolescent reported being on a diet. The dependent variable in Panel B is an indicator for whether the adolescent reported having no reason to diet. The dependent variable in Panel C is an indicator for whether the adolescent reported not being on a diet but feeling that s/he should gain weight. The dependent variable in Panel D is an indicator for whether the adolescent reported not being on a diet but feeling that s/he should lose weight. Observations are limited to the region of Europe indicated on the horizontal axis. The circles plot the estimates, and the vertical lines denote the corresponding 95% confidence intervals. The estimates are obtained using a two-stage least squares strategy shown in Equation (3) where birth month relative to the school entry cutoff is an instrument for relative age and the average age of comparable classroom peers is used as an instrument for absolute age. The estimates utilize the sample weights. Standard errors are clustered at the classroom level.



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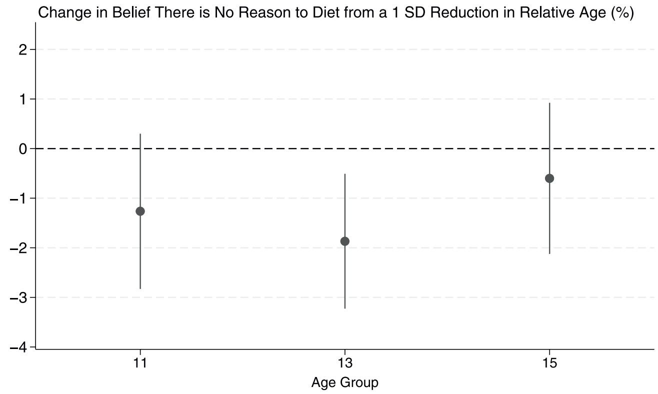
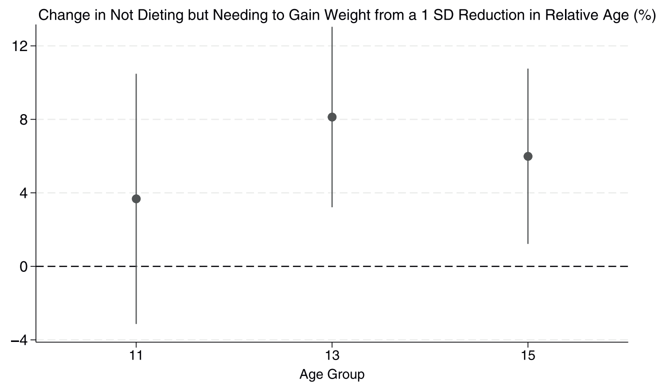


(B)



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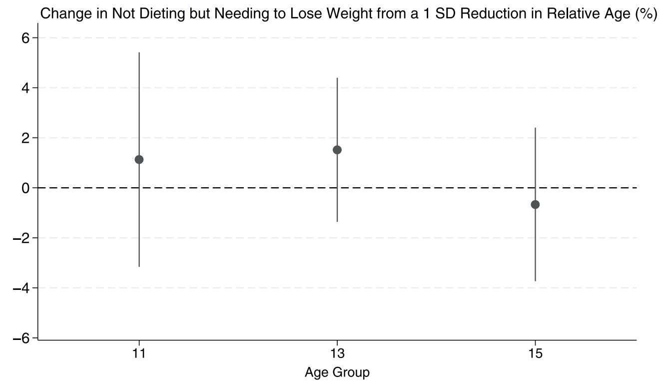


(D)

FIGURE A7 | Relationship between relative age and dieting behaviors, by age group. *Source:* Health behaviour in school-aged children, 2002–2018. The figures plot the percentage change relative to the sample mean associated with a one standard deviation reduction in relative age. The dependent variable in Panel A is an indicator for whether the adolescent reported being on a diet. The dependent variable in Panel B is an indicator for whether the adolescent reported having no reason to diet. The dependent variable in Panel C is an indicator for whether the adolescent reported not being on a diet but feeling that s/he should gain weight. The dependent variable in Panel D is an indicator for whether the adolescent reported not being on a diet but feeling that s/he should lose weight. Observations are limited to the age category indicated on the horizontal axis. The circles plot the estimates, and the vertical lines denote the corresponding 95% confidence intervals. The estimates are obtained using a two-stage least squares strategy shown in Equation (3) where birth month relative to the school entry cutoff is an instrument for relative age and the average age of comparable classroom peers is used as an instrument for absolute age. The estimates utilize the sample weights. Standard errors are clustered at the classroom level.

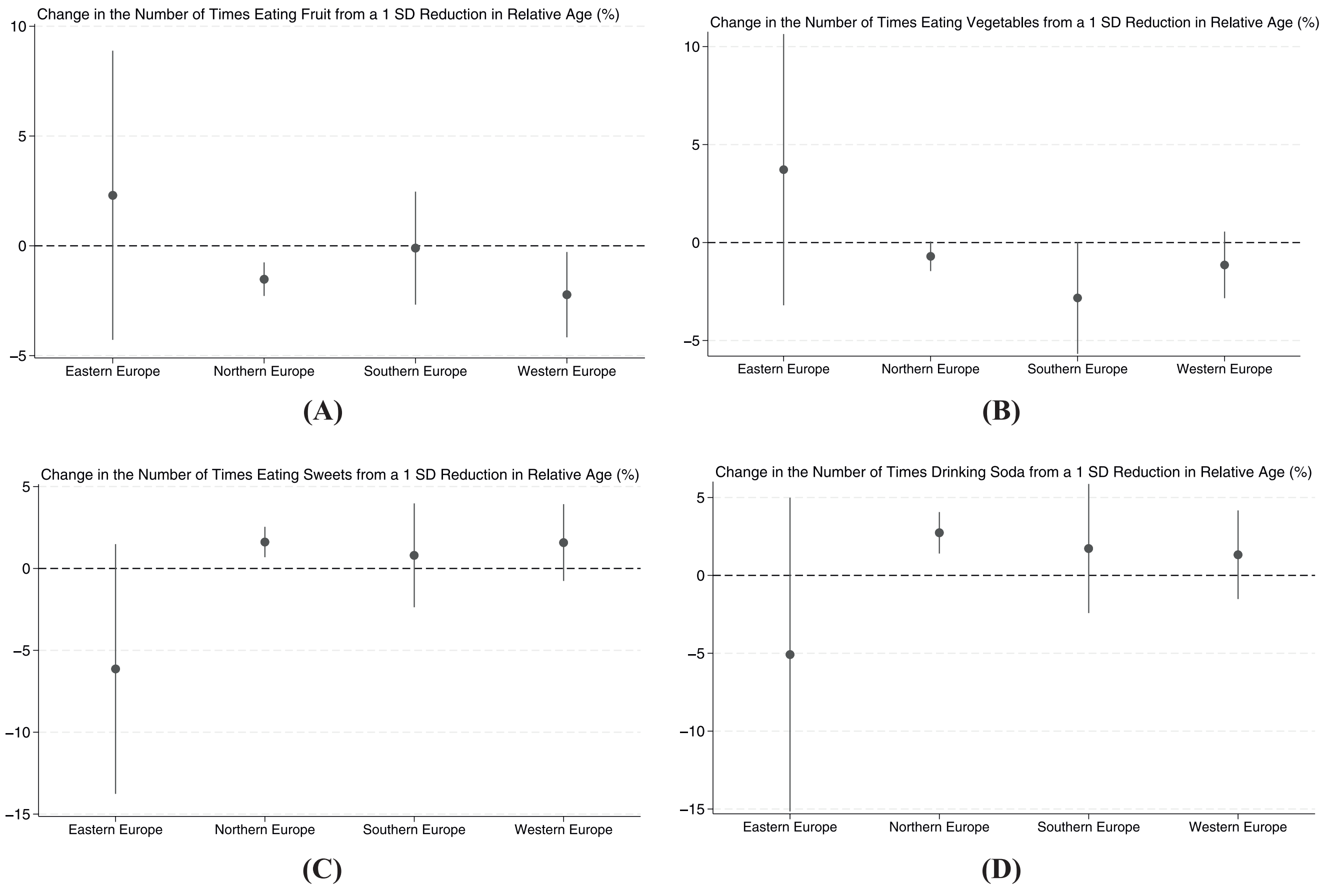
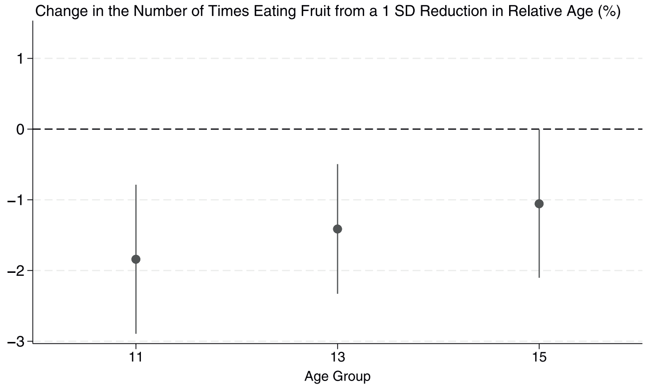
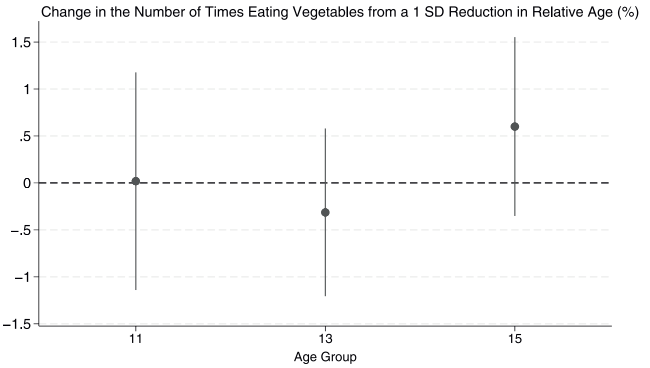


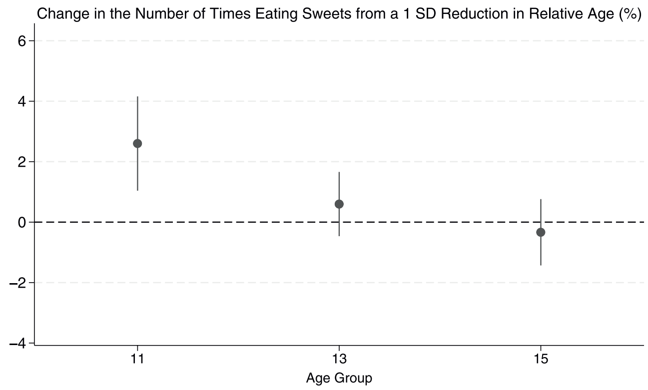
FIGURE A8 | Relationship between relative age and nutritional intake, by region of Europe. *Source:* Health behaviour in school-aged children, 2002–2018. The figures plot the percentage change relative to the sample mean associated with a one standard deviation reduction in relative age. The dependent variable in Panel A is the number of times the adolescent reported consuming fruit each week. The dependent variable in Panel B is the number of times the adolescent reported consuming vegetables each week. The dependent variable in Panel C is the number of times the adolescent reported consuming sweets each week. The dependent variable in Panel D is the number of times the adolescent reported consuming soda each week. Observations are limited to the region of Europe indicated on the horizontal axis. The circles plot the estimates, and the vertical lines denote the corresponding 95% confidence intervals. The estimates are obtained using a two-stage least squares strategy shown in Equation (3) where birth month relative to the school entry cutoff is an instrument for relative age and the average age of comparable classroom peers is used as an instrument for absolute age. The estimates utilize the sample weights. Standard errors are clustered at the classroom level.



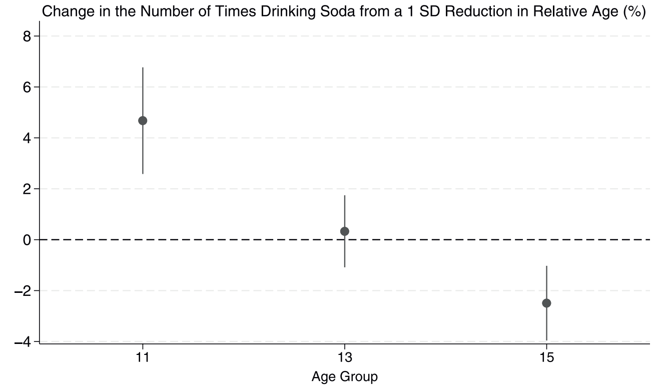
(A)



(B)



(C)



(D)

FIGURE A9 | Relationship between relative age and nutritional intake, by age group. *Source:* Health behaviour in school-aged children, 2002–2018. The figures plot the percentage change relative to the sample mean associated with a one standard deviation reduction in relative age. The dependent variable in Panel A is the number of times the adolescent reported consuming fruit each week. The dependent variable in Panel B is the number of times the adolescent reported consuming vegetables each week. The dependent variable in Panel C is the number of times the adolescent reported consuming sweets each week. The dependent variable in Panel D is the number of times the adolescent reported consuming soda each week. Observations are limited to the age category indicated on the horizontal axis. The circles plot the estimates, and the vertical lines denote the corresponding 95% confidence intervals. The estimates are obtained using a two-stage least squares strategy shown in Equation (3) where birth month relative to the school entry cutoff is an instrument for relative age and the average age of comparable classroom peers is used as an instrument for absolute age. The estimates utilize the sample weights. Standard errors are clustered at the classroom level.

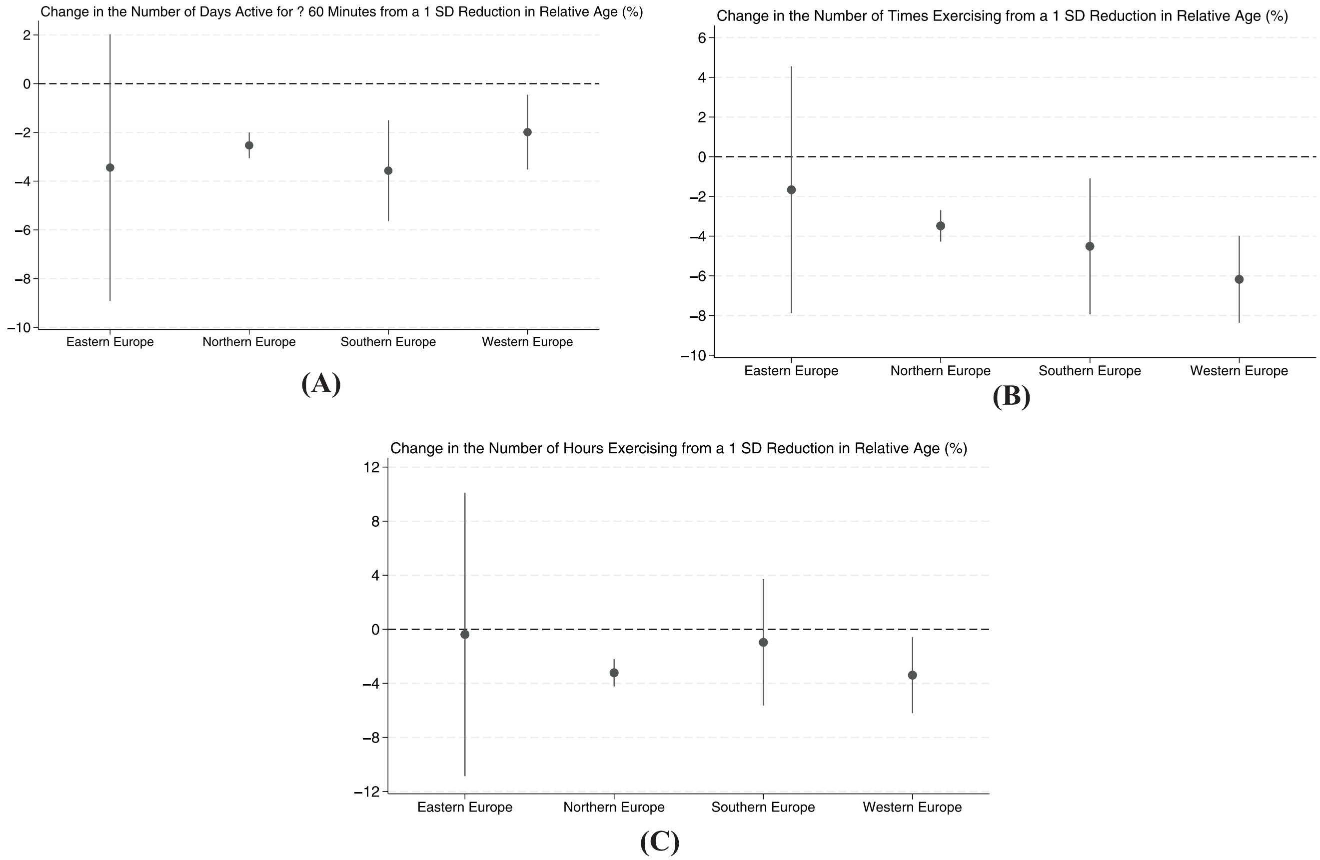


FIGURE A10 | Relationship between relative age and physical activity, by region of Europe. *Source:* Health behaviour in school-aged children, 2002–2018. The figures plot the percent change relative to the sample mean associated with a one standard deviation reduction in relative age. The dependent variable in Panel A is the number of days that the adolescent reported being active for at least 60 min during the past week. The dependent variable in Panel B is the number of times the adolescent reported exercising outside of school during the past week. The dependent variable in Panel C is the number of hours the adolescent reported exercising outside of school during the past week. Observations are limited to the region of Europe indicated on the horizontal axis. The circles plot the estimates, and the vertical lines denote the corresponding 95% confidence intervals. The estimates are obtained using a two-stage least squares strategy shown in Equation (3) where birth month relative to the school entry cutoff is an instrument for relative age and the average age of comparable classroom peers is used as an instrument for absolute age. The estimates utilize the sample weights. Standard errors are clustered at the classroom level.

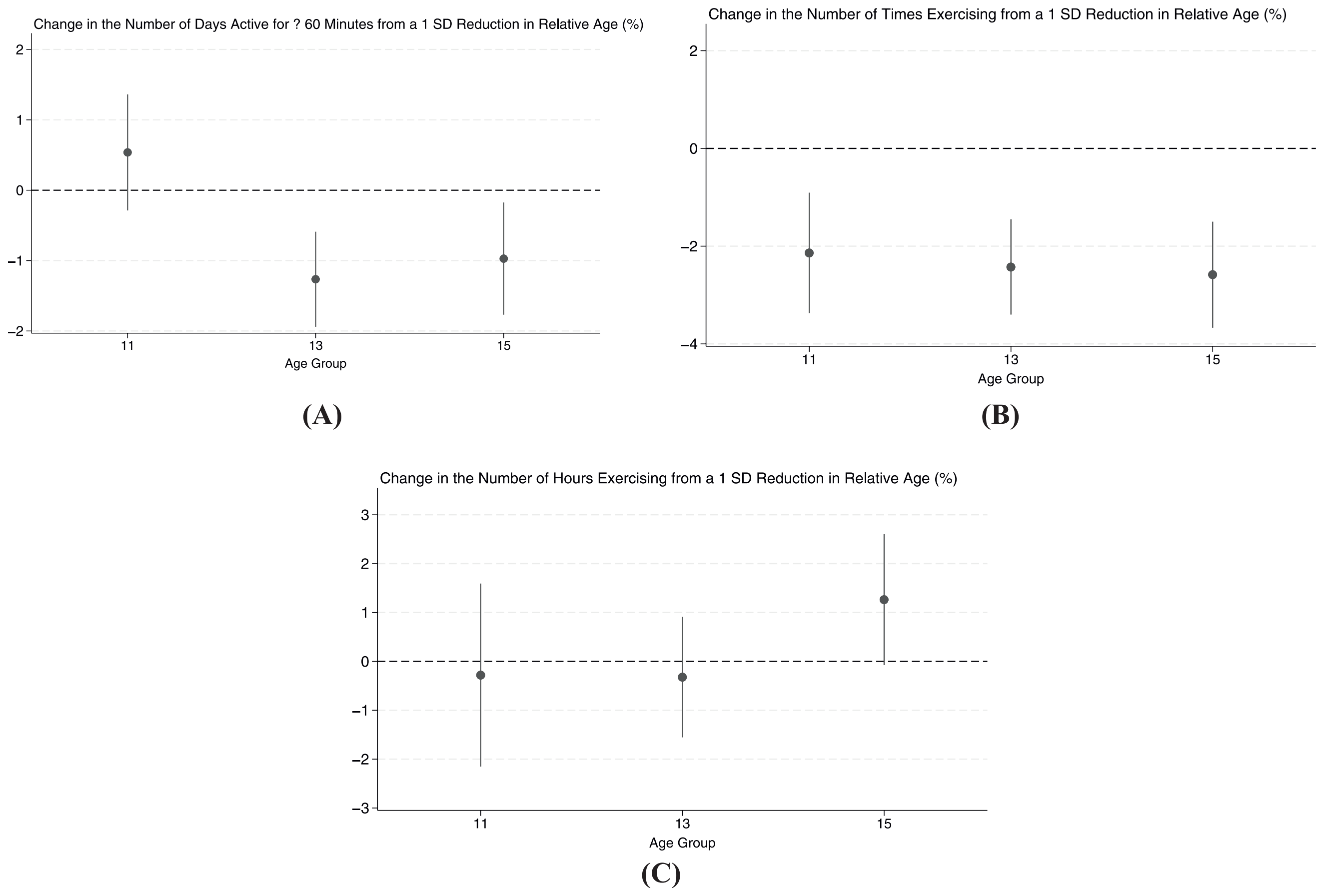


FIGURE A11 | Relationship between relative age and physical activity, by age group. *Source:* Health behaviour in school-aged children, 2002–2018. The figures plot the percent change relative to the sample mean associated with a one standard deviation reduction in relative age. The dependent variable in Panel A is the number of days that the adolescent reported being active for at least 60 min during the past week. The dependent variable in Panel B is the number of times the adolescent reported exercising outside of school during the past week. The dependent variable in Panel C is the number of hours the adolescent reported exercising outside of school during the past week. Observations are limited to the age category indicated on the horizontal axis. The circles plot the estimates, and the vertical lines denote the corresponding 95% confidence intervals. The estimates are obtained using a two-stage least squares strategy shown in Equation (3) where birth month relative to the school entry cutoff is an instrument for relative age and the average age of comparable classroom peers is used as an instrument for absolute age. The estimates utilize the sample weights. Standard errors are clustered at the classroom level.

TABLE A1 | Additional summary statistics.

	(1) Mean	(2) Std. dev.	(3) Minimum	(4) Maximum	(5) Observations
Weight	50.975	13.093	19	150	505,980
Height	161.614	11.828	120	256	503,290
Girl	0.511	0.500	0	1	572,889
Mom at home	0.946	0.225	0	1	572,889
Dad at home	0.790	0.407	0	1	572,889
Low socioeconomic status	0.272	0.445	0	1	572,889
Middle socioeconomic status	0.364	0.481	0	1	572,889
High socioeconomic status	0.364	0.481	0	1	572,889

Note: The summary statistics utilize the sample weights.
Source: Health Behaviour in School-Aged Children, 2002–2018. The summary statistics utilize the sample weights.

TABLE A2 | School entry cutoff dates.

Country	Cutoff
Austria	September 1st
Belgium, Flanders	January 1st
Belgium, Wallonia	January 1st
Bulgaria	January 1st
Croatia	April 1st
Czech Republic	September 1st
Denmark	January 1st
England	September 1st
Estonia	October 1st
Finland	January 1st
France	January 1st
Greece	January 1st
Greenland	January 1st
Hungary	July 1st
Iceland	January 1st
Ireland	January 1st
Italy	January 1st
Latvia	January 1st
Lithuania	January 1st
Luxembourg	September 1st
Macedonia	January 1st
Malta	January 1st
Netherlands	October 1st
Norway	January 1st
Poland	September 1st
Scotland	March 1st
Slovakia	September 1st
Slovenia	January 1st
Spain	January 1st
Sweden	January 1st
Switzerland	July 1st
Ukraine	January 1st
Wales	September 1st

Source: Fumarco and Baert (2019).

TABLE A3 | Relationship between the instrumental variables and the righthand side demographic characteristics.

Outcome →	(1) Age	(2) Girl	(3) Mom at home	(4) Dad at home	(5) Low SES	(6) Middle SES	(7) High SES
Expected relative age	0.030***	−0.001**	0.000	0.000	−0.000**	−0.000	0.001**
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Country FE?	Y	Y	Y	Y	Y	Y	Y
Survey wave FE?	Y	Y	Y	Y	Y	Y	Y
Birth month FE?	Y	Y	Y	Y	Y	Y	Y
Observations	572,889	572,889	572,889	572,889	572,889	572,889	572,889

Note: The dependent variable in column 1 is the student's age, in column 2 an indicator for whether the student is a girl, in column 3 for whether the student's mother is at home, in column 4 for whether the student's father is at home, in column 5 for whether the student is classified as low socioeconomic status, in column 6 for whether the student is classified as middle socioeconomic status, and in column 7 for whether the student is classified as high socioeconomic status. The estimates report reduced form results where the independent variable of interest is the student's birth month relative to the school entry cutoff month. The regressions include country fixed effects, survey wave fixed effects, and month-of-birth fixed effects. The estimates utilize the sample weights. Standard errors, shown in parentheses, are clustered at the classroom level.

Source: Health behaviour in school-aged children, 2002–2018.

*$p < 0.10$.

**$p < 0.05$.

***$p < 0.01$.

TABLE A4 | Extended coefficients from the two-stage least squares relationship between relative age and body perception.

Outcome →	(1)	(2) Body perception	(3)
Sample →	All adolescents	Adolescent girls	Adolescent boys
1 SD ↓ relative age	−0.029***	−0.025***	−0.033***
	(0.005)	(0.006)	(0.007)
Age	0.024***	0.051***	−0.003***
	(0.001)	(0.001)	(0.002)
Girl	0.344***		
	(0.002)		
Middle SES	0.016***	0.015***	0.019***
	(0.003)	(0.004)	(0.004)
High SES	0.037***	0.033***	0.043***
	(0.003)	(0.004)	(0.004)
Mom in the household	−0.003	−0.009	−0.000
	(0.006)	(0.009)	(0.008)
Dad in the household	−0.013***	−0.028***	0.005
	(0.003)	(0.004)	(0.004)
Survey year FE?	Y	Y	Y
Country FE?	Y	Y	Y
Month of birth FE?	Y	Y	Y
F-statistic	4854.70	3869.92	2933.72
Mean	−0.011	0.156	−0.184
Standard deviation	0.769	0.758	0.740
Observations	462,765	236,030	226,735

Note: The dependent variable is the student's self-perception relative to his or her BMI. The regressions are estimated via the two-stage least squares specification shown in Equation (3). Column 1 is the full sample of adolescents, column 2 limits the sample to adolescent girls, and column 3 limits the sample to adolescent boys. The estimates utilize the sample weights. Standard errors, shown in parentheses, are clustered at the classroom level.

Source: Health behaviour in school-aged children, 2002–2018.

*$p < 0.10$.

**$p < 0.05$.

***$p < 0.01$.

TABLE A5 | The two-stage least squares relationship between relative age and body image is robust to excluding observations from the tails of the height, weight, and relative age distributions.

	(1)	(2)	(3)	(4)
		Excluding the top and bottom of the distribution		
Sample →	**All adolescents**	**1%**	**5%**	**10%**
Panel A: Height				
1 SD ↓ relative age	−0.029***	−0.030***	−0.029***	−0.030***
	(0.005)	(0.005)	(0.005)	(0.005)
F-statistic	4854.70	4829.96	4614.23	4290.26
Mean	−0.011	−0.009	0.017	0.036
Standard deviation	0.769	0.767	0.756	0.758
Observations	462,765	458,931	419,901	375,851
Panel B: Weight				
1 SD ↓ relative age	−0.029***	−0.028***	−0.026***	−0.026***
	(0.005)	(0.005)	(0.005)	(0005)
F-statistic	4854.70	4831.71	4596.98	4224.46
Mean	−0.011	−0.005	0.010	0.027
Standard deviation	0.769	0.766	0.750	0.748
Observations	462,765	459,412	420,586	370,236
Panel C: Relative age				
1 SD ↓ relative age	−0.029***	−0.025***	−0.020***	−0.010***
	(0.005)	(0.004)	(0.003)	(0.002)
F-statistic	4854.70	5667.45	8554.25	22,039.02
Mean	−0.011	−0.011	−0.011	−0.008
Standard deviation	0.769	0.769	0.767	0.768
Observations	462,765	458,205	422,148	375,707

Note: The dependent variable is the student's self-perception relative to his or her BMI. This value is constructed by taking the difference between a variable denoting how the student described his or her body and a variable denoting the student's BMI status corresponding to his or her reported height and weight. The former variable takes on the value of 1 if the student describes his or her body as "much too thin," 2 if the student describes his or her body as "a bit too thin," 3 if the student describes his or her body as "about the right size," 4 if the student describes his or her body as "a bit too fat," and 5 if the student describes his or her body as "much too fat." The latter variable takes on the value of 1 if the student is classified as "severely thin," 2 for those classified as "thin," 3 for those classified as "normal weight," 4 for those classified as "overweight," and 5 for those classified as "obese." Positive values indicate that the student described his or her body as heavier than indicated by the clinically relevant WHO BMI category implied by his or her reported height and weight. The regressions are estimated via the two-stage least squares specification shown in Equation (3). Panel A examines the sensitivity of the results to outliers in terms of heights, Panel B in terms of weight, and Panel C in terms of relative age. Column 1 examines the full sample, column 2 excludes the top and bottom 1% of observations, column 3 excludes the top and bottom 5% of observations, and column 4 excludes the top and bottom 10% of observation. The estimates utilize the sample weights. Standard errors, shown in parentheses, are clustered at the classroom level.
Source: Health behaviour in school-aged children, 2002–2018.
*$p < 0.10$.
**$p < 0.05$.
***$p < 0.01$.

TABLE A6 | The relationship between relative age and body image is robust to dropping students born around the school entry cutoff month.

Months excluded around the cutoff →	**(1)** **+/− 1 Month**	**(2)** **+/− 2 Months**	**(3)** **+/− 3 Months**
1 SD ↓ relative age	−0.021***	−0.015**	−0.023**
	(0.006)	(0.007)	(0.010)
F-statistic	4216.35	3713.03	2863.29
Mean	−0.010	−0.011	−0.011
Standard deviation	0.768	0.768	0.768
Observations	391,503	321,869	246,044

Note: The dependent variable is the student's self-perception relative to his or her BMI. This value is constructed by taking the difference between a variable denoting how the student described his or her body and a variable denoting the student's BMI status corresponding to his or her reported height and weight. The former variable takes on the value of 1 if the student describes his or her body as "much too thin," 2 if the student describes his or her body as "a bit too thin," 3 if the student describes his or her body as "about the right size," 4 if the student describes his or her body as "a bit too fat," and 5 if the student describes his or her body as "much too fat." The latter variable takes on the value of 1 if the student is classified as "severely thin," 2 for those classified as "thin," 3 for those classified as "normal weight," 4 for those classified as "overweight," and 5 for those classified as "obese." Positive values indicate that the student described his or her body as heavier than indicated by the clinically relevant WHO BMI category implied by his or her reported height and weight. The estimates are obtained using a two-stage least squares strategy shown in Equation (3) where birth month relative to the school entry cutoff is an instrument for relative age and the average age of comparable classroom peers is used as an instrument for absolute age. Column 1 drops students born the month prior to the school entry cutoff and the month of the school entry cutoff. Column 2 drops students born 2 months prior to the cutoff month, the cutoff month, or the month following the cutoff. Column 3 drops students born 3 months prior to the cutoff month, during the cutoff month, or the 2 months following the cutoff months. The estimates utilize the sample weights. Standard errors, shown in parentheses, are clustered at the classroom level.
Source: Health behaviour in school-aged children, 2002–2018.
*$p < 0.10$.
**$p < 0.05$.
***$p < 0.01$.

TABLE A7 | The relationship between relative age and body misperception throughout the survey window.

Outcome →	**(1)** **2002**	**(2)** **2006**	**(3)** **2010**	**(4)** **2014**	**(5)** **2018**
1 SD ↑ relative age	−0.034***	−0.030***	−0.035***	−0.023**	−0.018
	(0.013)	(0.010)	(0.011)	(0.010)	(0.013)
F-statistic	837.191	982.916	1291.278	1449.988	898.768
Mean	0.025	0.015	−0.018	−0.017	−0.062
Standard deviation	0.761	0.761	0.755	0.781	0.786
Observations	84,111	101,492	105,043	87,673	84,446

Note: The dependent variable is the student's self-perception relative to his or her BMI. This value is constructed by taking the difference between a variable denoting how the student described his or her body and a variable denoting the student's BMI status corresponding to his or her reported height and weight. The former variable takes on the value of 1 if the student describes his or her body as "much too thin," 2 if the student describes his or her body as "a bit too thin," 3 if the student describes his or her body as "about the right size," 4 if the student describes his or her body as "a bit too fat," and 5 if the student describes his or her body as "much too fat." The latter variable takes on the value of 1 if the student is classified as "severely thin," 2 for those classified as "thin," 3 for those classified as "normal weight," 4 for those classified as "overweight," and 5 for those classified as "obese." Positive values indicate that the student described his or her body as heavier than indicated by the clinically relevant WHO BMI category implied by his or her reported height and weight. The estimates are obtained from the two-stage least squares specification shown in Equation (3). Each column limits the sample to the single survey wave shown in the header. The estimates utilize the sample weights. Standard errors, shown in parentheses, are clustered at the classroom level.
Source: Health behavior in school-aged children, 2002–2018.
*$p < 0.10$.
**$p < 0.05$.
***$p < 0.01$.

TABLE A8 | Two-stage least squares relationship between relative age and body image, by bullying victimization.

	(1)	(2)	(3)
		Body image	
Outcome →	Bullied at school	Sample is adolescents bullied at school	Sample is adolescents not bullied at school
Panel A: All adolescents			
1 SD ↓ relative age	0.004*	−0.044***	−0.026***
	(0.003)	(0.011)	(0.005)
F-statistic	5977.256	1731.012	4633.231
Mean	0.280	0.021	−0.023
Standard deviation	0.449	0.832	0.744
Observations	554,245	123,387	324,869
Panel B: Adolescent girls			
1 SD ↓ relative age	0.001	−0.036**	−0.022***
	(0.003)	(0.015)	(0.007)
F-statistic	4947.219	1172.586	3470.993
Mean	0.266	0.211	0.137
Standard deviation	0.442	0.824	0.733
Observations	284,700	60,042	169,115
Panel C: Adolescent boys			
1 SD ↓ relative age	0.008**	−0.052***	−0.031***
	(0.004)	(0.017)	(0.008)
F-statistic	3685.764	927.891	2614.264
Mean	0.295	−0.158	−0.195
Standard deviation	0.456	0.799	0.717
Observations	269,545	63,345	155,754

Note: The dependent variable in column 1 is an indicator for whether the student reports being bullied at school. The dependent variable in columns 2 and 3 is the student's self-perception relative to his or her BMI. The estimates are obtained using a two-stage least squares strategy shown in Equation (3) where birth month relative to the school entry cutoff is an instrument for relative age and the average age of comparable classroom peers is used as an instrument for absolute age. Panel A examines all adolescents, Panel B examines adolescent girls, and Panel C examines adolescent boys. The estimates utilize the sample weights. Standard errors, shown in parentheses, are clustered at the classroom level.
Source: Health behaviour in school-aged children, 2002–2018.
*$p < 0.10$.
**$p < 0.05$.
***$p < 0.01$.

TABLE A9 | The relationship between relative age and body image is found throughout the distribution of average classroom BMI.

Average classroom BMI →	(1) First quartile	(2) Middle two quartiles	(3) Top quartile
Panel A: All adolescents			
1 SD ↓ relative age	−0.029**	−0.029***	−0.019*
	(0.012)	(0.006)	(0.010)
F-statistic	733.947	2608.678	1545.106
Mean	0.082	0.003	−0.124
Standard deviation	0.754	0.755	0.796
Observations	105,192	242,696	114,877
Panel B: Adolescent girls			
1 SD ↓ relative age	−0.013	−0.021**	−0.037***
	(0.016)	(0.008)	(0.013)
F-statistic	623.358	2086.207	1206.493
Mean	0.209	0.167	0.081
Standard deviation	0.753	0.751	0.773
Observations	55,518	124,691	55,821

(Continues)

TABLE A9 | (Continued)

Average classroom BMI →	(1) First quartile	(2) Middle two quartiles	(3) Top quartile
Panel C: Adolescent boys			
1 SD ↓ relative age	−0.048**	−0.038***	0.001
	(0.019)	(0.009)	(0.015)
F-statistic	414.948	1602.225	919.828
Mean	−0.058	−0.170	−0.318
Standard deviation	0.731	0.720	0.768
Observations	49,674	118,005	59,056

Note: The dependent variable is the student's self-perception relative to his or her BMI. This value is constructed by taking the difference between a variable denoting how the student described his or her body and a variable denoting the student's BMI status corresponding to his or her reported height and weight. The estimates are obtained using a two-stage least squares strategy shown in Equation (3) where birth month relative to the school entry cutoff is an instrument for relative age and the average age of comparable classroom peers is used as an instrument for absolute age. Column 1 limits the sample to adolescents in classrooms found in the bottom quartile of the average classroom BMI distribution, column 2 limits the sample to adolescents in classrooms in the middle two quartiles of the distribution, and column 3 limits the sample to adolescents in the top quartile of the distribution. Panel A examines all adolescents, Panel B examines adolescent girls, and Panel C examines adolescent boys. The estimates utilize the sample weights. Standard errors, shown in parentheses, are clustered at the classroom level.
Source: Health behaviour in school-aged children, 2002–2018.
*$p < 0.10$.
**$p < 0.05$.
***$p < 0.01$.

TABLE A10 | The two-stage least squares relationship between relative age and body perception, by age and sex.

Age category →	(1) Overall	(2) 11	(3) 13	(4) 15
Panel A: All adolescents				
1 SD ↓ relative age	−0.029***	−0.043***	−0.015**	−0.020***
	(0.005)	(0.008)	(0.006)	(0.006)
F-statistic	4854.70	1257.98	1800.17	1453.27
Mean	−0.011	−0.081	0.022	0.021
Standard deviation	0.769	0.777	0.763	0.763
Observations	462,765	145,202	158,185	159,378
Panel B: Adolescent girls				
1 SD ↓ relative age	−0.025***	−0.040***	−0.011	−0.013
	(0.006)	(0.011)	(0.008)	(0.009)
F-statistic	3869.92	987.19	1474.62	1150.74
Mean	0.156	0.036	0.180	0.241
Standard deviation	0.758	0.763	0.758	0.740
Observations	236,030	73,350	80,635	82,045
Panel C: Adolescent boys				
1 SD ↓ relative age	−0.033***	−0.045***	−0.017**	−0.024***
	(0.007)	(0.012)	(0.009)	(0.009)
F-statistic	2933.72	909.59	1159.00	954.55
Mean	−0.184	−0.199	−0.141	−0.211
Standard deviation	0.741	0.773	0.733	0.716
Observations	226,735	71,852	77,550	77,333

Note: The dependent variable is the student's self-perception relative to his or her BMI. This value is constructed by taking the difference between a variable denoting how the student described his or her body and a variable denoting the student's BMI status corresponding to his or her reported height and weight. The former variable takes on the value of 1 if the student describes his or her body as "much too thin," 2 if the student describes his or her body as "a bit too thin," 3 if the student describes his or her body as "about the right size," 4 if the student describes his or her body as "a bit too fat," and 5 if the student describes his or her body as "much too fat." The latter variable takes on the value of 1 if the student is classified as "severely thin," 2 for those classified as "thin," 3 for those classified as "normal weight," 4 for those classified as "overweight," and 5 for those classified as "obese." Positive values indicate that the student described his or her body as heavier than indicated by the clinically relevant WHO BMI category implied by his or her reported height and weight. The regressions are estimated via the two-stage least squares specification shown in Equation (3). Panel A examines all adolescents, Panel B examines adolescent girls, and Panel C examines adolescent boys. Column 1 uses the full sample. Column 2 limits the sample to 11-year-old adolescents, column 3 limits the sample to 13-year-old adolescents, and column 4 limits the sample to 15-year-old adolescents. The estimates utilize the sample weights. Standard errors, shown in parentheses, are clustered at the classroom level.
Source: Health behaviour in school-aged children, 2002–2018.
*$p < 0.10$.
**$p < 0.05$.
***$p < 0.01$.

TABLE A11 | The relationship between relative age and bmi is robust to dropping students born around the school entry cutoff Month.

Months excluded around the cutoff →	**(1)** **+/− 1 Month**	**(2)** **+/− 2 Months**	**(3)** **+/− 3 Months**
1 SD ↑ relative age	−0.123***	−0.109***	−0.150***
	(0.024)	(0.030)	(0.045)
F-statistic	4314.62	3775.449	2878.848
Mean	19.395	19.399	19.408
Standard deviation	3.405	3.402	3.400
Observations	403,080	331,469	253,443

Note: The dependent variable is the adolescent's BMI. The estimates are obtained using a two-stage least squares strategy shown in Equation (3) where birth month relative to the school entry cutoff is an instrument for relative age and the average age of comparable classroom peers is used as an instrument for absolute age. Column 1 drops students born the month prior to the school entry cutoff and the month of the school entry cutoff. Column 2 drops students born 2 months prior to the cutoff month, the cutoff month, or the month following the cutoff. Column 3 drops students born 3 months prior to the cutoff month, during the cutoff month, or the 2 months following the cutoff months. The estimates utilize the sample weights. Standard errors, shown in parentheses, are clustered at the classroom level.
Source: Health behaviour in school-aged children, 2002–2018.
*$p < 0.10$.
**$p < 0.05$.
***$p < 0.01$.

TABLE A12 | Two-stage least squares relationships between relative age, weight, and height.

Outcome →	**(1)** **Weight (kg)**	**(2)** **Height (cm)**
1 SD ↓ relative age	0.436***	0.060
	(0.064)	(0.054)
F-statistic	5298.792	5279.894
Mean	50.975	161.614
Standard deviation	13.093	11.828
Observations	505,980	503,290

Note: The dependent variable in column 1 is the adolescent's weight (in kilograms) and in column 2 the adolescent's height (in centimeters). The estimates are obtained using a two-stage least squares strategy shown in Equation (3) where birth month relative to the school entry cutoff is an instrument for relative age and the average age of comparable classroom peers is used as an instrument for absolute age. The estimates utilize the sample weights. Standard errors, shown in parentheses, are clustered at the classroom level.
Source: Health behaviour in school-aged children, 2002–2018.
*$p < 0.10$.
**$p < 0.05$.
***$p < 0.01$.