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Cross-national time trends in adolescent body weight perception and the explanatory role of overweight/obesity prevalence

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ABSTRACT

Introduction: Body weight perception (BWP) is associated with health behaviors. Current evidence points to an increase over time in both actual and perceived weight status among adolescents, however there is limited evidence on time trends in BWP in cross-national samples of adolescents. Therefore, the aims of this study were to examine time trends in BWP between 2002 and 2018 among adolescents from 41 countries and regions, including gender and country differences and to explore the role of changes over time in country-level overweight/obesity prevalence in these trends.

Methods: Data were used from five cycles (2002, 2006, 2010, 2014, 2018) of the repeated cross-sectional Health Behavior in School-Aged Children (HBSC) study ($n = 746{,}121$; mean±standard deviation age 13.7 ± 1.6 years, 51.0% girls). Multilevel logistic models estimated cross-national linear time trends in adolescent BWP (correct perception, underestimation, or overestimation), adjusted for gender, age, and family affluence. Next, we tested whether country-level

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changes over time overweight/obesity prevalence could explain these trends in BWP among adolescents.
Results: Correct weight perception increased over time among girls, while it decreased among boys. Underestimation of weight status increased, and overestimation of weight status decreased over time among both genders, with stronger trends for girls. Furthermore, country differences in trends in both BWP and overweight/obesity were found. Changes over time in country-level overweight/obesity prevalence could not explain these trends.
Conclusion: The linear increase over time in correct weight perception and the decrease in overestimation may have a positive effect on unhealthy weight reduction behaviors among adolescents. However, the increase in underestimation could signal a need for interventions to strengthen correct weight perception among adolescents. Several implications for policy and practice are discussed.

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KEYWORDS Body weight congruence; weight perception; overweight; obesity; adolescents; trends

Introduction

Body weight misperception occurs when there is a discrepancy between one's perceived weight status and their actual weight status (Sonneville et al. 2016). This misperception can be either an underestimation or an overestimation. In the case of underestimation, the actual weight status is higher than the perception (e.g. individuals with overweight perceive themselves as normal weight). In the case of an overestimation, it is the other way around, i.e. the actual weight status is lower than the perceived status (e.g. individuals with normal weight perceive themselves as overweight). Body weight misperception is rather common during adolescence (Kern et al. 2020) and underestimation of weight status seems to be particularly common among adolescents with overweight/obesity (Sonneville et al. 2016; Hahn et al. 2018). Body weight misperception in adolescence has been associated with changes in actual weight status (Sutin and Terracciano 2015; Rancourt et al. 2017), weight-loss intentions (Fan and Jin 2015), as well as mental health problems (Elia et al. 2020). Adolescents of normal weight who misperceive themselves as being overweight tend to engage in unhealthy dieting practices and behaviors that are conducive to obesity (Sutin and Terracciano 2015). Furthermore, they have greater odds of becoming obese over the 12-year follow-up period than adolescents who perceive their weight accurately (Sutin and Terracciano 2015). As changes overtime in body weight perception (BWP) have been reported (Quick et al. 2014; Lu et al. 2015; Whitehead et al. 2017), this paper goes one step further and aims to investigate time trends in adolescent BWP and explore whether these changes are associated

with changes in the proportion of adolescent overweight/obesity rates at country level.

Both overweight/obesity and BWP might have changed over time among adolescents. A study that included data from 24 mainly European countries found that country-level overweight prevalence increased among adolescents between 2001/2002 and 2009/2010 (Quick et al. 2014). Girls and boys with overweight were respectively 68% and 10% more likely to underestimate their weight status, while girls and boys with underweight or normal weight were respectively 15% and 12% less likely to overestimate their weight status over time. However, when analyses were controlled for country-level overweight prevalence, the changes in BWP over time became non-significant (Quick et al. 2014). It is plausible that the observed changes in BWP could be explained by country-level overweight prevalence (Robinson 2017). The underlying mechanism may be reference norms, i.e. the proportion of overweight among individuals in the immediate environment influencing the assessment of one's own weight. If there are more individuals with overweight, this may lead to overweight being regarded as the norm by more and more individuals, so that individuals with overweight no longer perceive themselves as overweight. An increase in underestimation of weight status is also observed among American adolescents with overweight/obesity (Lu et al. 2015). Another study that used data from the National Longitudinal Study of Adolescent to Adult Health found that American adolescents residing in counties with a higher overweight prevalence are less likely to see themselves as overweight compared to those residing in counties with a low overweight prevalence (Wedow et al. 2018). They also found that overweight prevalence during adolescence is related to BWP throughout adolescence and into young adulthood (Wedow et al. 2018). Given the current evidence around increasing trends in adolescent overweight and obesity, there is a need to investigate contemporary trends in BWP among cross-national representative samples of adolescents (World Health Organization 2020).

BWP might also differ by gender. For example, data from several countries (e.g. Australia, Thailand, China, United States) indicate that girls are more likely to overestimate their weight status compared to boys, whereas boys are more likely to underestimate it (Xie et al. 2003; Herbert et al. 2017; Sirirassamee et al. 2018; Gaylis et al. 2020). In addition, it seems that girls are more likely to report having tried to control their weight, whereas boys are likely to have tried gaining weight or never tried to control their weight (Gaylis et al. 2020). Weight norms can have a stronger influence on perceived weight status among girls compared to boys, and the role of gender is particularly important during adolescence (Wedow et al. 2018). Girls with a normal weight status are less likely to perceive their weight status correctly than boys (Dzielska et al. 2020; Fismen et al. 2022). However, there is limited

evidence around gender differences in BWP among contemporary cohorts of adolescents.

In summary, evidence suggested that adolescent BWP might have changed over time (Quick et al. 2014; Lu et al. 2015), however previous studies focused either on underestimation of weight status among adolescents with overweight/obesity and overestimation in adolescents with underweight/normal weight or they only used data from a single country. Therefore, the aim of this study was twofold. Firstly, we aimed to examine linear time trends in BWP between 2002 and 2018 among adolescents from 41 countries, including gender and country differences. Secondly, we aimed to investigate the explanatory role of changes over time in country-level overweight/obesity prevalence in these trends.

Methods

Study population and design

We used data from the Health Behavior in School-Aged Children (HBSC) study, a World Health Organization collaborative cross-sectional cross-national study, that has been conducted every 4 years since 1983 to monitor and improve understanding of health and health behaviors and their context in the lives of adolescents (Inchley et al. 2018). For this study, we included data from 2002 until 2018 (survey years: 2002, 2006, 2010, 2014, and 2018). Participating countries/regions with data on 3 or more time points were eligible for inclusion in the analyses. During each survey round, different nationally representative samples of 11-, 13-, and 15-year-olds completed an internationally standardized questionnaire at school. The primary sampling unit was class or school. Institutional ethical consent was obtained from the institutional ethics committee(s) or any relevant board in each country. Informed active consent of parents (or guardians) and the participants in the study was required in most of the countries, while a minority of countries used informed passive consent. Oral and written information outlining the confidentiality of their responses was provided and answers were anonymized.

The final sample (HBSC data 2002 to 2018) included data from 1,030,627 adolescents from 41 countries/regions in total. Data from Albania, Azerbaijan, Georgia, Kazakhstan, Republic of Moldova, Serbia, and Turkey were excluded as they had data available from less than three time points (n = 45,055). Data on height and weight was complete for 799,822 participants (n = 185,750 missing), of whom 774,362 participants also had available data on perceived weight status (n = 25,460 missing). An additional 28,241 participants had missing data on family affluence. The data used in the analyses included 746,121 adolescents from 41 countries or regions (n = 380,757

[51.0%] girls; mean [standard deviation; SD] age = 13.6 [1.6] years) with complete data on weight status, BWP and confounders.

Measurements

Weight status

Weight status was based on self-reported weight and height as reported to the following questions: "How much do you weigh without clothes?" and "How tall are you without shoes?". Body mass index (BMI) was calculated, and weight status was defined according to the international standardized age- and sex specific cutoff points proposed by Cole and Lobstein for the International Obesity Task Force (IOFT) (Cole and Lobstein 2012). We combined the IOFT classes into 3 groups: "underweight", "normal weight", and "overweight/obese". Self-reported height and weight is considered a reliable proxy measure across age, sex, and race/ethnicity subpopulations of adolescents (Pérez et al. 2015). Implausible values on height and weight were identified as system missing data by the HBSC Data Management Centre.

Body weight perception

Perceived weight status was assessed with the question: "Do you think your body is?" with the possible answers: "much too thin", "a bit too thin", "about the right size", "a bit too fat" and "much too fat". This item was developed by the HBSC study and has shown good test-retest stability (intraclass correlation [95% confidence interval [CI] = 0.81[0.76;0.85]) (Ojala et al. 2012). To assess BWP, weight status (0 = underweight, 1 = normal weight, 2 = overweight/obese) and perceived weight status (0 = much too thin/a bit too thin, 1 = about the right size, 2 = a bit too fat/much too fat) were coded numerically. Participants were categorized as either *correct weight perception* (congruence perceived weight status and weight status), *underestimation of weight status* (perceived weight status lower than weight status) or *overestimation of weight status* (perceived weight status higher than weight status).

Confounders

Adolescents reported their gender (i.e. boy or girl), year and month of birth. Relative family affluence was assessed to measure socioeconomic status using the 4-item HBSC Family Affluence Scale (Currie et al. 2008), that includes four items about the family's household. The individual sum-scores were transformed into proportional ranks that indicate adolescents' relative family affluence in their residential country. The scores were then categorized into

the lowest 20%, middle 60%, and highest 20% within each country. Country-level overweight/obesity prevalence was calculated by the percentage overweight/obese per country.

Statistical analyses

Analyses were conducted in Stata 17.0 (StataCorp, College Station, TX, USA). Logistic and multilevel logistic regression models were performed using the *meqrlogit* command to assess time trends in BWP (StataCorp 2013). The HBSC sampling plan uses classes or schools as the primary sampling unit. Therefore, the data is nested: adolescents > classes/schools > country. The *svyset* command accounts for this nested structure by country. Furthermore, our data analysis approach accounts for this nested data structure by adding weights to the primary sampling unites and performing analyses stratified by country. We performed several models for respectively correct weight perception, underestimated weight status and overestimated weight status. The first model included survey year (as a continuous variable), gender, age, and family affluence on the individual level to investigate linear changes over time. To assess gender differences, we tested the interactions of gender with survey year on BWP in Model 1. Model 2 added country on the second level to assess whether potential time trends differ by country. The likelihood ratio test assessed whether the added country variance in the multilevel model was significant. Model 3 added country-level overweight/obesity prevalence to examine the contribution of country-level overweight/obesity prevalence on potential time trends in BWP. Time trends in overweight/obesity were assessed using models 1 and 2. In addition, to describe country-specific time trends between 2002 and 2018 in BWP and overweight/obesity, we performed logistic regression models controlled for survey year, sex, age, and family affluence stratified per country. A 2-sided p-value <.05 was considered statistically significant.

Results

General characteristics of the study sample

Table 1 shows the general characteristics of the study sample. Participants had a mean age of 13.7 ± 1.6 years and 51.0% were girls. Across all survey years, more than half of the participants (60.9%) had a correct weight perception, while 13.7% of the participants underestimated their weight status and 25.4% overestimated their weight status. The prevalence of self-reported overweight/obesity in our study population was 14.4% (11.5% for girls and 17.4% for boys).

Table 1. Characteristics of the study sample.

Variable	n (%)
Total	746,121
Number of countries/regions	41
Survey wave	
2002	133,334 (17.8)
2006	160,906 (21.6)
2010	160,746 (21.5)
2014	147,351 (19.8)
2018	143,784 (19.3)
Gender	
Boys	365,364 (49.0)
Girls	380,757 (51.0)
Age group	
11 years	227,640 (30.5)
13 years	255,085 (34.2)
15 years	263,395 (35.3)
Body weight perception	
Correct weight perception	454,415 (60.9)
Underestimation weight status	102,425 (13.7)
Overestimation weight status	189,281 (25.4)
Overweight/obese	107,627 (14.4)
Family affluence	
Low	147,141 (19.7)
Medium	448,411 (60.1)
High	150,569 (20.2)

Note: Data are unweighted.

Trends in body weight perception

Table 2 shows the overall time trends in BWP in Model 1. A linear increase over time was found for correct weight perception (odds ratio [OR], 95% CI per year = 1.001[1.001;1.002], $p = 0.002$) and for underestimation of weight status (OR per year = 1.017[1.016;1.018], $p < .001$), while a linear decrease was found for overestimation of weight status (OR per year = 0.987 [0.986;0.988], $p < .001$). Compared to boys, girls had lower odds to correctly perceive their weight status (OR = 0.742[0.735; 0.749], $p < .001$) and to underestimate their weight status (OR = 0.400[0.394;0.405], $p < .001$). To the contrary, girls had higher odds to overestimate their weight status (OR = 2.622[2.593;2.651], $p < .001$) compared to boys.

Gender differences

Significant interactions were found for being a girl with survey year on correct weight perception (OR = 1.011[1.009;1.012], $p < .001$), underestimation of weight status (OR = 1.005[1.003;1.008], $p < .001$), and overestimation of weight status (OR = 0.994[0.992;0.996], $p < .001$), which suggested that time trends differ by gender. Stratified analyses by gender are shown in Table 3. Over time boys showed a decrease in correct weight perception (OR = 0.995[0.994;0.997], $p < .001$), while girls reported an increase in

correct weight perception (OR = 1.007[1.006;1.008], $p < .001$). Underestimation of weight status increased over time among both genders, but this time trend was slightly stronger among girls (OR = 1.022 [1.020;1.024], $p < .001$) compared to boys (OR = 1.015[1.013;1.016], $p < .001$). The linear time trends in the overestimation of weight status decreased among both genders but marginally stronger among girls (OR = 0.985[0.984;0.986], $p < .001$) compared to boys (OR = 0.992[0.990;0.993], $p < .001$).

Country differences

By adding the country level (Tables 2–3; Model 2) to the models, the model fit significantly improved compared to the logistic Model 2, as indicated by significant chibar2 values from the likelihood ratio test (StataCorp 2013). This means that there is significant unexplained variance across countries. Stratified analyses by country for linear time trends for BWP and overweight/obesity are shown in Table 4. Fifteen of the 41 countries showed an increase in correct weight perception, while eight countries showed a decrease in correct weight perception. More than half of the countries (22/41) showed an increase in underestimation of weight status, while only five countries (Finland, Greenland, The Netherlands, Portugal, and Romania) showed a decrease in underestimation of weight status. Overestimation of weight status increased in four countries (Denmark, Greenland, Russia, and Slovakia) but decreased in 25 countries.

Trends in overweight/obesity

Linear time trends in overweight/obesity are shown in Table 5. Overall, there was an increase in overweight/obesity (OR per year = 1.023 [1.022;1.024], $p < .001$, Model 1). There was a significant interaction for being a girl with survey year on overweight/obesity (OR = 1.004 [1.002;1.006], $p < .001$). Stratified analyses by gender showed a stronger increase for girls (OR = 1.027[1.025;1.028], $p < .001$, Model 1) compared to boys (OR = 1.020[1.019;1.022], $p < .001$, Model 1). Furthermore, there were country differences as shown by a significantly improved model fit in Models 2 (Table 5). An increase in overweight/obesity was observed in 28 countries, while a decrease in overweight/obesity was observed in four countries (Denmark, England, Spain, and Wales; Table 4).

Table 2. Time trends in body weight perception and the explanatory role of overweight/obesity prevalence.

	Model 1 OR (95% CI)	Model 2 OR (95% CI)	Model 3 OR (95% CI)
Correct weight perception			
Log likelihood value	−497121.16	−495038.22	−495036.13
Fixed effects			
Survey year	1.001 (1.001;1.002)**	1.001 (1.000;1.002)	1.001 (1.000;1.002)
Being girl	0.742 (0.735; 0.749)***	0.739 (0.732; 0.746)***	0.739 (0.732; 0.746)***
Age	0.974 (0.971;0.977)***	0.974 (0.971;0.976)***	0.974 (0.971;0.976)***
Medium FAS[a]	1.040 (1.028;1.053)***	1.041 (1.029;1.054)***	1.041 (1.029;1.054)***
High FAS[a]	1.028 (1.013;1.043)***	1.034 (1.019;1.050)***	1.034 (1.019;1.050)***
Country overweight/obesity prevalence	-	-	1.011 (1.001;1.022)*
Random effects			
Country variance	-	0.023 (0.015;0.036)	0.021 (0.014;0.033)
LR test vs. logistic model (chibar2)	-	4165.87***	3838.55***
Underestimation weight status			
Log likelihood value	−289192.29***	−286326.38	−286311.97
Fixed effects			
Survey year	1.017 (1.016;1.018)***	1.015 (1.014;1.016)***	1.015 (1.014;1.016)***
Being girl	0.400 (0.394;0.405)***	0.396 (0.390;0.401)***	0.396 (0.390;0.401)***
Age	1.014 (1.010;1.018)***	1.010 (1.005;1.014)***	1.009 (1.005;1.014)***
Medium FAS[a]	0.878 (0.863;0.893)***	0.881 (0.866;0.896)***	0.881 (0.866;0.896)***
High FAS[a]	0.810 (0.793;0.828)***	0.826 (0.808;0.844)***	0.826 (0.808;0.844)***
Country overweight/obesity prevalence	-	-	1.047 (1.033;1.062)***
Random effects			
Country variance	-	0.078 (0.050;0.121)	0.038 (0.025;0.60)
LR test vs. logistic model (chibar2)	-	5731.82***	2815.03***
Overestimation weight status			
Log likelihood value	−406635.69	−400278.41	−400268.66
Fixed effects			
Survey year	0.987 (0.986;0.988)***	0.989 (0.988;0.990)***	0.989 (0.988;0.990)***
Being girl	2.622 (2.593;2.651)***	2.679 (2.649;2.709)***	2.679 (2.649;2.709)***
Age	1.025 (1.022;1.028)***	1.030 (1.027;1.033)***	1.030 (1.027;1.033)***

(*Continued*)

Table 2. (Continued).

	Model 1 OR (95% CI)	Model 2 OR (95% CI)	Model 3 OR (95% CI)
Medium FAS[a]	1.035 (1.020;1.049)***	1.028 (1.014;1.043)***	1.028 (1.014;1.043)***
High FAS[a]	1.107 (1.089;1.126)***	1.083 (1.065;1.102)***	1.083 (1.065;1.102)***
Country overweight/obesity prevalence	-	-	0.954 (0.936;0.972)***
Random effects			
Country variance	-	0.110 (0.071;0.170)	0.068 (0.044;0.106)
LR test vs. logistic model (chibar2)	-	12714.57***	8415.10***

Note: $n = 746{,}121$. OR indicate odds ratio; CI, confidence interval; FAS, Family Affluence Scale; LR test, likelihood ratio test. [a] Low FAS is reference group. *$p < .05$. **$p < .01$. ***$p < .001$.

Model 1: included survey year (as a continuous variable), gender, age, and family affluence on the individual level.

Model 2: additional included country on the second level.

Model 3: additional included country-level overweight/obesity prevalence.

Table 3. Time trends in body weight perception and the explanatory role of country-level overweight/obesity prevalence stratified by gender.

	Boys ($n = 365,364$)			Girls ($n = 380,757$)		
	Model 1 OR (95% CI)	Model 2 OR (95% CI)	Model 3 OR (95% CI)	Model 1 OR (95% CI)	Model 2 OR (95% CI)	Model 3 OR (95% CI)
Correct weight perception						
Log likelihood value	−237548.73	−236971.82	−236971.67	−259409.78	−257360.35	−257355.21
Fixed effects						
Survey year	0.995 (0.994;0.997)***	0.995 (0.994;0.997)***	0.995 (0.994;0.997)***	1.007 (1.006;1.008)***	1.006 (1.005;1.007)***	1.006 (1.005;1.007)***
Age	0.993 (0.989;0.997)**	0.994 (0.989;0.998)**	0.994 (0.989;0.998)**	0.958 (0.955;0.962)***	0.955 (0.952;0.959)***	0.955 (0.952;0.959)***
Medium FAS[a]	1.066 (1.047;1.085)***	1.065 (1.046;1.084)***	1.065 (1.046;1.084)***	1.017 (1.000;1.038)	1.027 (1.010;1.045)**	1.027 (1.010;1.045)**
High FAS[a]	1.070 (1.047;1.093)***	1.066 (1.043;1.089)***	1.066 (1.043;1.089)***	0.988 (0.967;1.009)	1.010 (0.989;1.031)	1.010 (0.989;1.031)
Country overweight/obesity prevalence	-	-	0.997 (0.989;1.006)	-	-	1.024 (1.010;1.038)**
Random effects						
Country variance	-	0.015 (0.010;0.024)	0.015 (0.010;0.024)	-	0.046 (0.030;0.072)	0.036 (0.023;0.056)
LR test vs. logistic model (chibar2)	-	1153.80***	1144.89***	-	4098.86***	3326.72***
Underestimation weight status						
Log likelihood value	−177005.27	−175489.07	−175478.24	−110582.88	−109061.7	−109045.31
Fixed effects						
Survey year	1.015 (1.013;1.016)***	1.013 (1.011;1.014)***	1.013 (1.011;1.014)***	1.022 (1.020;1.024)***	1.020 (1.017;1.022)***	1.020 (1.017;1.022)***
Age	1.104 (1.099;1.110)***	1.101 (1.095;1.106)***	1.101 (1.095;1.106)***	0.865 (0.859;0.871)***	0.858 (0.852;0.864)***	0.858 (0.852;0.864)***
Medium FAS[a]	0.902 (0.883;0.921)***	0.903 (0.884;0.923)***	0.903 (0.884;0.923)***	0.836 (0.812;0.860)***	0.851 (0.827;0.876)***	0.851 (0.826;0.875)***

(*Continued*)

Table 3. (Continued).

	Boys ($n = 365{,}364$)			Girls ($n = 380{,}757$)		
	Model 1 OR (95% CI)	Model 2 OR (95% CI)	Model 3 OR (95% CI)	Model 1 OR (95% CI)	Model 2 OR (95% CI)	Model 3 OR (95% CI)
High FAS[a]	0.860 (0.838;0.883)***	0.869 (0.846;0.892)***	0.869 (0.846;0.892)***	0.722 (0.696;0.749)***	0.752 (0.724;0.780)***	0.752 (0.724;0.780)***
Country overweight/obesity prevalence	-	-	1.038 (1.024;1.052)***	-	-	1.063 (1.046;1.082)***
Random effects						
Country variance	-	0.062 (0.040;0.096)	0.036 (0.023;0.056)	-	0.128 (0.83;0.199)	0.057 (0.036;0.089)
LR test vs. logistic model (chibar2)	-	3032.41***	1666.81***	-	3042.36***	1369.87***
Overestimation weight status						
Log likelihood value	−162382.93	−160021.16	−160014.67	−242587.15	−238249.03	−238238.61
Fixed effects						
Survey year	0.992 (0.990;0.993)***	0.994 (0.992;0.995)***	0.994 (0.992;0.995)***	0.985 (0.984;0.986)***	0.987 (0.986;0.988)***	0.987 (0.986;0.988)***
Age	0.906 (0.901;0.911)***	0.908 (0.903;0.913)***	0.908 (0.903;0.913)***	1.103 (1.098;1.107)***	1.111 (1.106;1.115)***	1.111 (1.106;1.115)***
Medium FAS[a]	1.011 (0.988;1.034)	1.012 (0.989;1.036)	1.012 (0.989;1.036)	1.050 (1.031;1.068)***	1.032 (1.014;1.051)**	1.032 (1.014;1.051)**
High FAS[a]	1.058 (1.029;1.088)***	1.056 (1.026;1.086)***	1.056 (1.026;1.086)***	1.139 (1.114;1.164)***	1.098 (1.074;1.123)***	1.098 (1.074;1.123)***
Country overweight/obesity prevalence	-	-	0.962 (0.944;0.981)***	-	-	0.949 (0.930;0.968)***
Random effects						
Country variance	-	0.101 (0.065;0.157)	0.073 (0.047;0.114)	-	0.128 (0.083;0.198)	0.077 (0.050;0.119)
LR test vs. logistic model (chibar2)	-	4723.55***	3377.81***	-	8676.24***	5701.97***

Note: OR indicate odds ratio; CI, confidence interval; FAS, Family Affluence Scale; LR test, likelihood ratio test. [a] Low FAS is reference group. * $p < .05$.** $p < .01$.*** $p < .001$.
Model 1: included survey year
(as a continuous variable), age, and family affluence on the individual level.
Model 2: additional included country on the second level.
Model 3: additional included country-level overweight/obesity prevalence.

Table 4. Time trends in body weight perception and overweight/obesity within countries.

	Correct weight perception		Underestimation weight status		Overestimation weight status		Overweight/obesity	
Country	2002	Change per year OR (95% CI)	2002	Change per year OR (95% CI)	2002	Change per year OR (95% CI)	2002	Change per year OR (95% CI)
Austria	60.6	1.003 (0.997;1.008)	13.4	1.017 (1.009;1.026)***	26.0	0.989 (0.984;0.995)***	13.5	1.022 (1.014;1.029)***
Armenia	61.0	0.997 (0.983;1.011)	14.0	1.014 (0.997;1.031)	25.1	0.990 (0.972;1.007)	12.3	1.016 (0.996;1.035)
Belgium (Flanders)	60.3	1.008 (1.003;1.013)**	13.2	1.010 (1.002;1.018)*	26.5	0.988 (0.983;0.993)***	13.3	1.011 (1.004;1.019)**
Belgium (Wallonia)	60.7	1.002 (0.996;1.008)	13.4	1.029 (1.020;1.039)***	25.9	0.986 (0.980;0.992)***	13.5	1.023 (1.015;1.032)***
Bulgaria	60.6	0.983 (0.976;0.990)***	13.9	1.046 (1.036;1.057)***	25.5	0.993 (0.985;1.001)	13.7	1.031 (1.021;1.041)***
Canada	60.8	1.005 (1.000;1.010)*	14.4	1.000 (0.990;1.001)	24.4	0.996 (0.991;1.001)	14.9	1.013 (1.008;1.019)***
Croatia	61.3	1.002 (0.998;1.007)	13.9	1.016 (1.010;1.023)***	24.8	0.982 (0.977;0.988)***	13.7	1.022 (1.016;1.029)***
Czech Republic	60.8	1.001 (0.998;1.005)	14.2	1.028 (1.023;1.033)***	25.0	0.974 (0.970;0.979)***	13.6	1.028 (1.022;1.034)***
Denmark	60.6	0.993 (0.987;0.998)**	13.3	0.996 (0.987;1.005)	26.1	1.010 (1.004;1.016)**	13.2	0.989 (0.981;0.998)*
England	60.6	0.998 (0.990;1.006)	13.7	0.998 (0.986;1.009)	25.7	1.004 (0.995;1.013)	13.6	0.979 (0.968;0.990)***
Estonia	60.8	0.992 (0.987;0.997)**	13.7	1.031 (1.024;1.039)***	25.5	0.990 (0.984;0.995)***	13.5	1.062 (1.054;1.070)***
Finland	61.0	1.009 (1.004;1.014)***	13.5	0.986 (0.979;0.993)***	25.4	0.997 (0.991;1.003)	13.6	1.006 (1.000;1.013)
France	61.1	1.000 (0.996;1.003)	13.1	1.010 (1.003;1.016)**	25.8	0.996 (0.992;1.001)	13.2	1.000 (0.994;1.006)
Germany	60.4	1.019 (1.014;1.023)***	13.5	1.006 (0.998;1.013)	26.1	0.976 (0.971;0.981)***	13.5	1.022 (1.015;1.029)***
Greece	61.0	0.984 (0.979;0.990)***	14.3	1.047 (1.040;1.054)***	24.8	0.977 (0.970;0.984)***	14.0	1.012 (1.005;1.018)***
Greenland	60.9	1.001 (0.988;1.015)	13.7	0.981 (0.964;0.998)*	25.4	1.018 (1.000;1.035)*	13.6	1.010 (0.994;1.027)
Hungary	60.8	1.013 (1.008;1.019)***	13.6	1.005 (0.997;1.013)	25.6	0.981 (0.975;0.987)***	13.7	1.029 (1.022;1.037)***
Iceland	61.5	1.003 (0.997;1.009)	13.7	1.015 (1.007;1.024)***	24.8	0.984 (0.977;0.991)***	13.6	1.000 (0.993;1.008)
Ireland	60.7	0.988 (0.978;0.997)*	13.7	1.018 (1.003;1.032)*	25.6	1.005 (0.994;1.016)	13.5	1.001 (0.988;1.015)
Israel	60.7	0.994 (0.987;1.001)	13.8	1.026 (1.016;1.036)***	25.5	0.990 (0.982;0.998)*	13.4	1.027 (1.016;1.037)***
Italy	61.3	0.993 (0.988;0.998)*	13.6	1.006 (0.998;1.013)	25.1	1.006 (1.000;1.013)	13.8	1.002 (0.996;1.009)
Latvia	60.9	1.008 (1.002;1.013)**	13.7	1.019 (1.011;1.027)***	25.5	0.978 (0.972;0.984)***	13.4	1.076 (1.067;1.085)***
Lithuania	60.8	1.000 (0.995;1.005)	13.6	1.027 (1.019;1.035)***	25.6	0.984 (0.978;0.990)***	13.2	1.078 (1.069;1.088)***
Luxembourg	60.7	1.018 (1.010;1.025)***	13.5	1.037 (1.025;1.050)***	25.8	0.964 (0.956;0.972)***	13.6	1.033 (1.023;1.044)***
Macedonia	61.1	1.000 (0.992;1.008)	13.9	1.077 (1.066;1.087)***	25.0	0.926 (0.916;0.936)***	13.8	1.053 (1.046;1.060)***
Malta	60.9	1.009 (1.000;1.019)*	13.9	1.004 (0.993;1.015)	25.3	0.977 (0.965;0.989)***	13.8	1.012 (1.002;1.022)***
Netherlands	60.4	1.010 (1.005;1.016)***	13.2	0.984 (0.975;0.994)**	26.4	0.993 (0.988;0.999)*	13.1	1.010 (1.000;1.019)*
Norway	60.7	1.002 (0.996;1.008)	13.4	1.029 (1.020;1.039)***	25.9	0.986 (0.980;0.992)***	13.5	1.023 (1.015;1.032)***

(*Continued*)

Table 4. (Continued).

	Correct weight perception		Underestimation weight status		Overestimation weight status		Overweight/obesity	
Country	2002	Change per year OR (95% CI)	2002	Change per year OR (95% CI)	2002	Change per year OR (95% CI)	2002	Change per year OR (95% CI)
Poland	59.9	1.009 (1.004;1.013)***	13.7	0.999 (0.993;1.005)	26.4	0.990 (0.985;0.995)***	13.5	1.048 (1.042;1.055)***
Portugal	60.9	1.013 (1.008;1.019)***	13.8	0.992 (0.985;0.999)*	25.3	0.988 (0.982;0.994)***	13.9	1.000 (0.994;1.007)
Romania	61.0	1.023 (1.015;1.031)***	13.9	0.986 (0.977;0.996)**	25.2	0.979 (0.970;0.988)***	13.6	1.038 (1.028;1.049)***
Russia	61.5	0.961 (0.957;0.966)***	13.5	1.045 (1.038;1.052)***	25.0	1.025 (1.020;1.031)***	13.1	1.058 (1.051;1.065)***
Scotland	60.6	0.997 (0.989;1.004)	13.6	1.002 (0.991;1.014)	25.7	1.003 (0.994;1.011)	13.6	1.008 (0.998;1.019)
Slovakia	61.0	0.977 (0.969;0.984)***	13.9	1.004 (0.994;1.013)	25.1	1.034 (1.025;1.044)***	13.6	1.048 (1.037;1.059)***
Slovenia	60.7	1.019 (1.014;1.023)***	13.6	1.016 (1.008;1.023)***	25.7	0.968 (0.963;0.973)***	13.8	1.013 (1.006;1.019)***
Spain	60.7	1.006 (1.002;1.011)**	14.0	1.000 (0.995;1.006)	25.2	0.991 (0.985;0.996)**	13.9	0.992 (0.987;0.998)**
Sweden	60.9	0.996 (0.990;1.001)	13.6	1.010 (1.002;1.017)*	25.5	1.000 (0.994;1.006)	13.4	1.024 (1.016;1.032)***
Switzerland	60.7	1.001 (0.996;1.005)	13.4	1.019 (1.011;1.026)***	26.0	0.991 (0.986;0.996)***	13.1	1.023 (1.015;1.030)***
Ukraine	61.0	0.995 (0.991;1.000)	13.4	1.003 (0.996;1.011)	25.6	1.004 (0.999;1.009)	13.1	1.036 (1.028;1.044)***
Wales	60.7	0.996 (0.990;1.001)	13.7	1.000 (0.992;1.007)	25.6	1.006 (0.999;1.012)	13.8	0.991 (0.984;0.997)**
USA	61.0	1.019 (1.008;1.030)***	13.9	1.023 (1.010;1.037)**	25.1	0.946 (0.934;0.959)***	14.2	1.024 (1.013;1.036)***

Note: OR indicate odds ratio; CI, confidence interval; USA, United States of America. Analyses are adjusted for gender, age, and family affluence.
*$p < .05$.**$p < .01$.***$p < .001$.

Table 5. Time trends in overweight/obesity stratified by gender.

	Total (n = 746,121)		Boys (n = 365,364)		Girls (n = 380,757)	
	Model 1 OR (95% CI)	Model 2 OR (95% CI)	Model 1 OR (95% CI)	Model 2 OR (95% CI)	Model 1 OR (95% CI)	Model 2 OR (95% CI)
Overweight/obesity						
Log likelihood value	−304102	−299749.97	−168564.2	−166050.19	−135367.43	−133328.08
Fixed effects						
Survey year	1.023 (1.022;1.024)***	1.024 (1.023;1.025)***	1.020 (1.019;1.022)***	1.020 (1.019;1.022)***	1.027 (1.025;1.028)***	1.029 (1.027;1.031)***
Being girl	0.617 (0.609;0.625)***	0.615 (0.606;0.623)***	-	-	-	-
Age	0.991 (0.987;0.995)***	0.983 (0.979;0.987)***	1.018 (1.013;1.023)***	1.012 (1.006;1.017)***	0.956 (0.950;0.962)***	0.946 (0.940;0.952)***
Medium FAS[a]	0.825 (0.811;0.838)***	0.819 (0.805;0.832)***	0.861 (0.843;0.880)***	0.852 (0.833;0.871)***	0.779 (0.760;0.798)***	0.776 (0.757;0.795)***
High FAS[a]	0.687 (0.673;0.701)***	0.686 (0.671;0.700)***	0.749 (0.728;0.769)***	0.744 (0.724;0.765)***	0.608 (0.588;0.628)***	0.609 (0.589;0.629) ***
Random effects						
Country variance	-	0.105 (0.068;0.163)	-	0.106 (0.069;0.164)	-	0.124 (0.080;0.192)
LR test vs. logistic model (chibar2)	-	8704.06***	-	5028.03***	-	4078.70***

Note: OR indicate odds ratio; CI, confidence interval; FAS, Family Affluence Scale; LR test, likelihood ratio test. [a] Low FAS is reference group. *$p < .05$.**$p < .01$.***$p < .001$.
Model 1: included survey year (as a continuous variable), gender (total only), age, and family affluence on the individual level.
Model 2: additional included country on the second level.

Explanatory role of trends in country-level overweight/obesity prevalence on trends in body weight perception

Overall, the increase in country-level overweight/obesity prevalence was associated with correct weight perception (OR = 1.011[1.001;1.022], p = 0.036; Table 2; Model 3), underestimation of weight status (OR = 1.047 [1.033;1.062], $p < .001$; Table 2; Model 3), and overestimation of weight status (OR = 0.954 [0.936;0.972], $p < .001$; Table 2; Model 3). When country-level overweight/obesity prevalence was added to the models, the model fit slightly improved (as indicated by the decrease in log likelihood values). However, the effect of survey year on BWP did not change, which means that the increase in country-level overweight/obesity prevalence was not associated with linear time changes in BWP.

Stratified analyses by gender showed that the increase in country-level overweight/obesity prevalence was associated with correct weight perception in girls (OR = 1.024[1.010;1.038], p=.001) but not in boys (OR = 0.997 [0.989;1.006], p=.577; Table 3, model 3). Furthermore, country-level overweight/obesity prevalence had a stronger effect on the underestimation of weight status for girls (OR = 1.063[1.046;1.082], $p < .001$) compared to boys (OR = 1.038[1.024;1.052], $p < .001$) and on the overestimation of weight status for girls (OR = 0.949[0.930;0.968], $p < .001$) compared to boys (OR = 0.962[0.944;0.981], $p < .001$).

Discussion

The purpose of this study was to investigate linear time trends between 2002 and 2018 in BWP among adolescents from 41 countries, including gender and country differences, as well as to investigate the explanatory role of country-level overweight/obesity prevalence in these trends. The results revealed a linear increase over time for correct weight perception among girls, while a linear decrease was observed among boys. Underestimation of weight status increased linearly over time, and overestimation of weight status decreased over time among both genders, though trends were slightly stronger for girls. Several country differences were found. The most obvious of them was an increase in underestimation of weight status over time in more than half of the countries included in our study. Country-level overweight/obesity prevalence was associated with a higher likelihood for correct weight perception among girls, while adolescents from both genders living in countries with a higher country-level overweight/obesity prevalence more often underestimated and less often overestimated their weight status. Furthermore, overweight/obesity increased over time. However, changes

over time in country-level overweight/obesity prevalence during the years of observation did not explain the overserved changes in BWP.

The observed gender differences in BWP might support the idea there are gender differences in body ideals and changes in body ideals over time. Previous research has reported on the idea that girls tend to internalize a thin body ideal, whereas boys' ideals are geared more toward muscularity (Grogan 2010; Tiggemann and Zaccardo 2016). Notably, the increased underestimation and decreased overestimation of weight status over time for girls may be explained by the emergence of an athletic and strong body, as the new contemporary body ideal for both boys and girls (Nagata et al. 2019). Moreover, attempts to gain weight are common among adolescent boys, irrespective of their weight (Nagata et al. 2019). The desired weight gain attempts among boys are muscle weight gains whereas at least traditionally, this may relate to gaining body fat for girls, which girls attempt to avoid. According to a recent study, the failure to perceive overweight is three times more prevalent among boys than among girls (Dzielska and Woynarowska 2022). This, along with cultural changes in the objectification of the male body (Pope et al. 2000), may explain the increase in body weight misperception among boys in our study. Important to note that girls more often rated themselves as too fat compared to boys during the entire research period 2002–2018, regardless of the overweight/obesity prevalence (WHO Regional Office for Europe). It might be that adolescent girls are more likely to have tried to lose or control weight by harmful means than boys (Ojala et al. 2012; Dion et al. 2015). In this light, the increase in correct weight perception and decrease in overestimation among girls can be interpreted as positive findings as less girls perform unnecessary and unhealthy weight reduction behaviors.

The observed country differences in BWP are not easily explainable but there may be some factors that require further investigation. Cross-national differences in body standards may lead to differences in BWP. Almost all countries with an increase in overweight/obesity prevalence showed an increase in underestimation of weight status and a decrease in overestimation of weight status. Though this can be partly explained by the operationalization of BWP (an increase in overweight/obesity leads to a reduction of overestimation of weight status by definition), this underlines the importance of relative social comparisons and development of weight perceptions. One factor that needs further investigation is migration status. Kern et al (Kern et al. 2020). found that both origin- and receiving country body standards were associated with BWP among the immigrant adolescents, with a stronger impact of receiving country standards. This underscores the context-sensitivity of adolescent BWP. Furthermore, adolescents living in more affluent families more often had a correct weight

perception but were also more likely to overestimate their weight status and less likely to underestimate their weight status. This is interesting as high socioeconomic status in western countries is associated with lower overweight/obesity rates (Wang and Lim 2012) and higher rates of body dissatisfaction, particularly among men (McLaren and Kuh 2004; McCabe and Ricciardelli 2004).

Implications

This study has clinical and public health implications. The observed decrease in underestimation of weight status among adolescents may be considered a public health challenge. BWP is an important factor in preventing obesity (Sutin and Terracciano 2015; Rancourt et al. 2017) and promoting weight loss or maintenance (Fan and Jin 2015). Fewer adolescents perceive themselves as overweight. As a result, less adolescents will be involved in weight reduction than before, reducing the effectiveness of public health interventions aimed at weight reduction. Cost-effective interventions such as World Health Organization (WHO) "best buys" have been identified to combat non-communicable diseases (World Health organization 2017). Though, policies and interventions need further implementation. This implementation demands involvement of multiple sectors, including governments, civil societies, general practitioners, and schools (Di Cesare et al. 2019). Schools play an important role in this. Programs focused on BWP, healthy diet, self-esteem, sport participation, and positive body image are encouraged. Hahn et al (Hahn et al. 2018). reported that body weight misperception among adolescents with overweight/obesity was associated with some beneficial weight-related health behaviors. Engagement in these healthy weight-related behaviors may protect against weight gain over time.

The observed decrease in overestimation may on the other side be considered encouraging, as overestimation of weight status is associated with unhealthy weight reduction behaviors (Ojala et al. 2012; Dion et al. 2015) and lower scores on mental health parameters (Fismen et al. 2022). The decrease in overestimation and increase of correct weight perception among girls may reflect an increase in positive body image, which is associated with health benefits (Burke et al. 2010). Changes may reflect the programs and efforts to emphasize functionality of one's body rather than on body size alone. Therefore, public health perspectives and health psychology perspectives must be combined when developing policy actions targeting adolescents BWP. Programs aimed at strengthening BWP via positive body image need to consider gender differences and take a holistic approach that include matters related to physical appearance but also adolescents' general sense of belonging, agency, and empowerment (Gattario and Frisén 2019).

Strengths and limitations

The strengths of the present study are the large number of participating countries, the long timespan of the study, the representative selection of participants, and the standardized method of survey. However, it should be noted that the study only included countries in the WHO Europe region as well as Canada and the United States of America, thus the results cannot be generalized to other regions.

Although a series of confounders were included in the models, there are other factors that might have an impact on these associations. Factors such as body image, dieting, changing eating patterns, and migration at individual level or increasing public health awareness towards obesity and increasing stigma towards people with obesity at country level might have played a role. Unfortunately, due to data availability these factors could not be included. Future research is needed to investigate the contribution of these factors on time trends in BWP. Comparisons have shown that self-reported height and weight data are not as accurate as corresponding physical measurements (Kurth and Ellert 2010; Karchynskaya et al. 2020); in particular, self-reported data underestimates the proportion of participants with overweight. However, self-reported height and weight is considered a reliable proxy measure across age, sex, and race/ethnicity subpopulations of adolescents (Pérez et al. 2015). Furthermore, physical measurements are not feasible for studies of the size of HBSC, and the comparisons have also shown that the discrepancies are negligible for epidemiologic purposes. Another limitation is that BMI could not be determined for 185,750 participants due to missing height and weight data. Studies have shown that participants with overweight/obesity proportionally often do not provide height and weight information (Kurth and Ellert 2010). This may have led to a healthier study sample and therefore associations may be underestimated. It is recommended to replicate the findings of the current study using studies based on physical measurements (e.g. *KiGGS Studie zur Gesundheit von Kindern und Jugendlichen in Deutschland*). However, such studies exist only at the level of single countries.

Conclusion

This study reported changes in BWP among adolescents from 41 countries, which could not be explained by an increase in country-level overweight/obesity prevalence. Changes in correct weight perception, underestimation and overestimation of weight status differed by gender and country. The increase in correct weight perception and the decrease in overestimation may have a positive effect on unhealthy weight reduction behaviors among adolescents, while the increase in underestimation might be a sign for the need for interventions to strengthen correct weight perception. More research is needed to

understand the factors underlying these time trends and to develop effective public health interventions.

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Data availability statement

The data that support the findings are available from the HBSC Data Management Centre at https://www.uib.no/en/hbscdata/113290/open-access.

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