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Weight status, quality of life, and cigarette smoking among adolescents in Washington State

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Abstract
Purpose We examine age- and sex-specific associations between weight status and intensity of cigarette smoking in a large sample of adolescents. Additionally, we test whether quality of life (QOL) and weight control behaviors (i.e., trying to lose, gain, or stay the same weight) mediate the association.
Methods We used cross-sectional data from the 2010 Washington State Healthy Youth Survey collected in grades 8, 10, and 12 ($n = 11{,}222$). Multinomial logistic regression was used to model cigarette smoking (none, light, frequent) as a function of weight status, weight control behaviors, and QOL by sex and age. Indirect effects of presumed mediators were assessed using the product of coefficients approach.
Results Weight status was not associated with smoking. Trying to stay the same weight was associated with lower odds of light smoking for younger girls (OR = 0.25; 95 % CI = 0.08, 0.84), whereas trying to lose weight was associated with higher odds of light smoking for older girls (OR = 1.73; 95 % CI = 1.11, 2.70). Low QOL was associated with higher odds of light and frequent smoking for both girls and boys ($P < 0.001$). The mediation effects of weight control behavior and QOL combined were significant in the associations between body mass index percentile and smoking among older girls.
Conclusion Targeted interventions designed to promote QOL and healthy weight control behaviors among youth may help to decrease the prevalence of smoking.

Keywords Weight status · Weight control behavior · Quality of life · Smoking · Adolescents · Mediation

Abbreviations

QOL	Quality of life
BMI	Body mass index
HYS	Healthy Youth Survey

Introduction

Overweight and obesity among children and adolescents continue to be public health concerns in the United States. Recent data indicate that for the last 10 years, 17 % of children and adolescents aged 2–19 years are obese, and an additional 15 % are overweight [1]. Childhood obesity is associated with type 2 diabetes, asthma, hypertension, and emotional distress [2–5]. Obese children are likely to be obese as adults, experience morbidity from diabetes and cardiovascular disease [6, 7], and incur higher health care costs [8, 9].

Relationships between overweight and obesity (hereafter weight status) and smoking in adolescents are different than those in adults [10–12]. Results from focus groups suggest that female smokers in high school smoke to control their weight and are reticent to quit smoking in case they gain weight [13]. In a summary of 55 primary research studies in adolescents [14], 19 studies assessed relationships between weight status and smoking, and 50 studies addressed youth weight concerns (i.e., perceived weight,

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general weight concerns, dieting behaviors, and restrained eating) and smoking. Of the studies assessing weight status and smoking, approximately half ($n = 9$) found a positive association, while the others showed no association or a negative association ($n = 10$). Results were inconsistent by sex. Evidence supporting a positive association between weight concerns and adolescent smoking differed by the dimension of weight concerns considered, with the strongest evidence for dieting behaviors. Across studies, smoking was associated with dieting behaviors, disordered eating symptoms, and general weight concerns, particularly among female adolescents. In other recent work, frequent smoking was significantly related to weight status among girls only, while smoking experimentation was not associated in any sex or age group [15]. Two longitudinal surveys found positive relationships between weight status and the probability of becoming a smoker in female adolescents [16, 17]; unhealthy weight status may lead to more frequent smoking [17]. In another 10-year cohort study, girls who perceived themselves to be overweight in grade 8 and 11 were more likely to be young adult smokers, for boys, body mass index (BMI) was a key predictor of future smoking [18]. However, other variables such as self-esteem, depression and quality of life were not included in the models [15, 18].

Psychosocial problems have an impact on smoking initiation in adolescence [19]. In some of the reviewed studies, significant bivariate associations between weight status and smoking became statistically insignificant when additional predictors were included, suggesting that predictors such as low self-esteem and negative mood may influence the observed associations [14]. Quality of life (QOL)—defined as the perception of position in life in the context of the culture and value systems in which youth live and in relation to their goals, expectations, standards, and concerns [20]—captures both internal and external influences on health behavior from the youth's perspective. Adolescents who engage in health-risk behaviors such as smoking report poorer perceived health-related QOL than do those who do not engage such behaviors [21]. Another study reported adolescents' substance use, including cigarette smoking, was significantly associated with reduced life satisfaction which is one aspect of QOL [22]. More recently, self-reported health, physical symptoms, psychological symptoms, depression, and school/social functioning were associated with smoking, in both younger and older girls; together, these variables explained some of the relationships between weight status and smoking [23]. However, the study did not include adolescent boys, and the outcomes did not account for intensity of smoking.

The current study contributes to existing literature by examining associations between smoking and weight status, taking into account the intensity of smoking, in a large sample of adolescents. Further, we test whether weight concerns and quality of life mediate the observed associations.

Methods

Sample and survey administration

In this cross-sectional cohort study, we analyzed data collected from 8th, 10th, and 12th grade youth in the Washington State 2010 Healthy Youth Survey (HYS) [24], Form B and form NS ($n = 11{,}222$). Since 2002, the HYS has been administered in English in October of every other year to assess risk/protective factors and health behaviors of youth in Washington State. The HYS uses a clustered sampling design in which schools are randomly selected and all students in participating schools are invited to complete the survey. For 8th, 10th, and 12th grades, respectively, the 2010 response rates were 90, 85, and 81 % for eligible school participation and 77, 67 and 53 % for student participation [24]. Parents had the opportunity to decline participation on behalf of their children and students could choose not to participate by telling their teacher. Before the survey is administered, students are informed that their answers are anonymous. The survey was administered to all participating students in a single class period during the school day. Students absent that day did not make up the survey. The study was reviewed and approved by the Washington State Institutional Review Board.

Of the total sample, those who were missing data to measure smoking status (0.3 %) or the independent variables (weight status, 11.6 %; weight control behavior, 2.2 %; and quality of life, 10.5 %) were excluded. Those who were underweight (2.3 % of the total sample) were excluded because of insufficient numbers for meaningful analysis. The final analysis sample included 8,702 students.

Variables

Smoking

One survey item was used to determine smoking status: "During the past 30 days, on how many days did you smoke cigarettes?" The original response options ("None", "1–2 days", "3–5 days", "6–9 days", "10–29 days", and "all 30 days") were collapsed into three groups ("None", "1–9 days", and "10–30 days") and labeled as no smoking, light smoking, and frequent smoking.

Weight status

Responses to questions about height and weight ("How tall are you without your shoes on?" and "How much do you weigh without your shoes on?") were used to calculate individual BMI (kg/m^2). For each sex, BMI-for-age percentiles were derived using the CDC 2000 growth chart [25]. Adolescents were considered to be normal weight if their age- and sex-adjusted BMI was at or above the 5th but less than the 85th percentile; overweight if their BMI was at or above the 85th but less than the 95th percentile; and obese if their BMI was at or above the 95th percentile. Weight status was set to missing if observations were missing age ($n = 9$) or gender ($n = 7$) or if body mass index (BMI; kg/m^2) was deemed biologically implausible based on established age- and sex-specific standards developed by the Centers for Disease Control and Prevention ($n = 129$) [26].

Weight concerns

A HYS survey question about weight control behaviors was used as a proxy measure of weight concerns. Specifically, participants were asked to categorize their goals related to their weight as: "not trying to do anything about my weight", "trying to lose weight", "trying to gain weight" or "trying to stay the same weight". Each category was coded as an indicator variable with "not trying to do anything about my weight" considered the reference category.

Quality of life

Quality of life was measured with 5 of 6 items of the Youth Quality of Life Instrument- Surveillance Version (YQOL-S) as fielded on the HYS 2010 administration ("I feel I am getting along with my parents or guardians", "I look forward to the future", "I feel good about myself", "I am satisfied with the way my life is now", "I feel alone in my life"), each measured on an 11-point scale ranging from not at all true (0) to completely true (10) [24]. The item "I feel alone in life" was reverse recoded so that higher scores indicated better quality of life. The items were transformed to a 0–100 point scale and summed to derive a total index score. The item and summary scores were dichotomized to distinguish "high" versus "low" quality of life, defined as one standard deviation (SD) below the sample mean [27]. By design, one item was not included in the index score for analyses because it has a different response scale than the other items, asking how similar the respondent feels compared to others her or his age, rather than what level in general they feel they are (D. Patrick, University of Washington, personal communication, 2011).

Demographic variables included age ($\leq$14 years or $\geq$15 years because the median age of onset for substance use is 15 years [28], gender (male, female), ethnicity (non-Hispanic White [reference], non-Hispanic Black, Hispanic, or other), and maternal education ($\leq$12 years, >12 years [reference] or missing).

Statistical analyses

Based on prior evidence [14, 15, 29], we tested age and sex as moderators of associations of weight status and smoking using partial F tests. Both age and sex were significant moderators; therefore, we present our findings stratified accordingly. Age- and sex-specific characteristics of the study participants—including the percentage of respondents reporting no smoking, light smoking, and frequent smoking—were summarized with descriptive statistics. Multinomial logistic regression was used to model cigarette smoking (none = reference category, light, frequent) as a function of weight status, weight control behaviors and quality of life. Results of the multinomial models are presented as the odds ratio (OR) and 95 % confidence interval (95 % CI) for a one unit change in the corresponding independent variable of being in a given smoking category (light or frequent) relative to no smoking.

We then tested the hypothesis that the relationship between weight status and smoking is mediated by weight control behavior and quality of life. Using the method of Baron and Kenny, the criteria for mediation are met if the following conditions hold for three regression equations [30]: First, weight status is associated with weight control behavior and/or quality of life, the presumed mediators; second, weight status is associated with smoking; and third, weight control behavior and/or quality of life are associated with smoking. Indirect effects of the two presumed mediators were estimated using the product of coefficients approach, and the bootstrap method was used to obtain standard errors and 95 % confidence intervals for the direct and indirect effects [31]. Confidence intervals that do not contain zero are significant for mediation. Continuous BMI percentile, dichotomous weight control behavior (any/none) and smoking (no vs. yes) were used for the mediation analysis in order to simplify the relationships.

All models were stratified by gender and age and were repeated with quality of life modeled as individual item scores. Models were also repeated with and without missing covariates imputed with the mode with no difference in findings. All statistical analyses were conducted with Stata, version 11, and took into account sampling weights, clusters and strata according to survey routines [32]. A probability less than or equal to 0.05 was considered statistically significant.

Results

Characteristics of the study sample

Most respondents were non-Hispanic White, and approximately half reported that their mothers had at least 12 years of education (Table 1). The prevalence of overweight was 16.66, 15.97, 15.35, and 13.35 % for younger boys, older boys, younger girls, older girls respectively. The prevalence of obesity was higher in boys (12.81 %—younger and 13.16 %—older) than in girls (9.06 %—younger and 6.96 %—older). More than 50 % of girls were trying to lose weight, while a higher proportion of boys reported no weight control behavior or trying to gain weight compared to girls. The mean quality of life scores was 79.79, 75.10, 73.59, and 72.71 for younger boys, older boys, younger girls, and older girls respectively.

Prevalence of smoking by intensity

The overall prevalence of self-reported smoking during the last 30 days was 6.79 % for light smoking and 5.04 % for frequent smoking. Older girls reporting "trying to lose weight" had significantly higher light cigarette smoking prevalence than their counterparts reporting "not trying to do anything about my weight" (9.33 vs. 4.96 %). Adolescents with low quality of life, whether measured with mean scores or individual items had a higher prevalence of cigarette smoking than adolescents with high quality of life. Thirty-two percent of older boys with a low score for the item "I feel I am getting along with my parents or guardians" reported either light or frequent cigarette smoking ($\sim$16 % for both), which was more than twice the prevalence among their counterparts with a high score for the same item (Tables 2, 3).

Table 1 Characteristics of study participants, 2010 Washington State Healthy Youth Survey (n = 8,702)

	Boys		Girls	
	≤14 years (n = 1,561)	≥15 years (n = 2,561)	≤14 years (n = 1,778)	≥15 years (n = 2,802)
Race/ethnicity: n (%)				
Non-Hispanic White	796 (50.99)	1,542 (60.21)	956 (53.77)	1,643 (58.64)
Non-Hispanic Black	82 (5.25)	106 (4.14)	72 (4.05)	90 (3.21)
Hispanic	191 (12.24)	301 (11.75)	206 (11.59)	372 (13.28)
Other	475 (30.43)	601 (23.47)	529 (29.75)	685 (24.45)
Data missing	17 (1.09)	11 (0.43)	15 (0.84)	12 (0.43)
Maternal education: n (%)				
≤12 years	448 (28.70)	823 (32.14)	532 (29.92)	965 (34.44)
>12 years	743 (47.60)	1,407 (54.94)	853 (47.98)	1,557 (55.57)
Data missing	370 (23.70)	331 (12.92)	393 (22.10)	280 (9.99)
Weight status: n (%)				
Normal	1,101 (70.53)	1,815 (70.87)	1,344 (75.59)	2,233 (79.69)
Overweight	260 (16.66)	409 (15.97)	273 (15.35)	374 (13.35)
Obese	200 (12.81)	337 (13.16)	161 (9.06)	195 (6.96)
Weight control behavior: n (%)				
None	560 (35.87)	841 (32.84)	414 (23.28)	605 (21.59)
Trying to lose weight	519 (33.25)	714 (27.88)	941 (52.92)	1,586 (56.60)
Trying to gain weight	168 (10.76)	599 (23.39)	59 (3.32)	80 (2.86)
Trying to stay the same weight	314 (20.12)	407 (15.89)	364 (20.47)	531 (18.95)
Quality of life: mean (SD)				
I feel I am getting along with my parents or guardians	79.35 (27.10)	74.36 (28.32)	72.95 (29.23)	71.44 (27.86)
I look forward to the future	82.81 (26.86)	81.13 (26.75)	81.70 (25.95)	84.35 (23.08)
I feel good about myself	80.45 (26.46)	76.84 (27.24)	71.52 (28.82)	69.82 (26.40)
I am satisfied with the way my life is now	75.73 (29.40)	69.34 (29.99)	67.93 (31.92)	66.65 (28.60)
I feel alone in my life	80.61 (30.85)	73.85 (32.40)	73.85 (33.90)	71.29 (31.93)
Mean quality of life score	79.79 (21.12)	75.10 (21.71)	73.59 (22.79)	72.71 (20.13)

Table 2 Percentage of respondents smoking cigarettes during the past 30 days, 2010 Washington State Healthy Youth Survey (boys)[a]

	Boys aged ≤14 years		Boys aged ≥15 years	
	Light smoking	Frequent smoking	Light smoking	Frequent smoking
Race/ethnicity	$n = 1{,}544$		$n = 2{,}550$	
Non-Hispanic White	4.02 (0.66)	1.76 (0.45)	8.56 (0.69)	9.66 (0.88)
Non-Hispanic Black	6.10 (2.44)	1.22 (1.24)	11.32 (3.10)	11.32 (3.14)
Hispanic	6.28 (1.72)	1.05 (0.72)	9.30 (1.74)	2.66 (0.80)
Other	2.53 (0.78)	1.47 (0.59)	7.49 (1.20)	6.99 (1.52)
Maternal education	$n = 1{,}191$		$n = 2{,}230$	
≤12 years	5.36 (1.04)	3.12 (0.89)	8.75 (1.01)	11.54 (1.31)
>12 years	2.83 (0.66)	0.54 (0.26)	8.96 (0.78)	6.61 (0.77)
Weight status	$n = 1{,}561$		$n = 2{,}561$	
Normal	3.63 (0.57)	1.36 (0.39)	8.15 (0.77)	7.77 (0.85)
Overweight	5.38 (1.30)	1.15 (0.66)	8.31 (1.33)	10.27 (1.62)
Obese	3.50 (1.48)	3.00 (1.08)	10.68 (2.10)	8.60 (2.00)
Weight control behavior	$n = 1{,}561$		$n = 2{,}561$	
None	3.39 (0.72)	1.43 (0.51)	7.25 (0.84)	9.04 (1.26)
Trying to lose weight	4.05 (0.82)	1.35 (0.53)	9.10 (1.24)	8.82 (1.17)
Trying to gain weight	5.36 (1.59)	1.79 (0.99)	9.35 (1.30)	7.18 (1.13)
Trying to stay the same weight	3.82 (1.00)	1.91 (0.87)	8.84 (1.45)	7.37 (1.10)
Quality of life[b]	$n = 1{,}561$		$n = 2{,}561$	
I feel I am getting along with my parents or guardians				
Low	8.29 (1.77)	6.08 (1.58)	15.61 (1.71)	16.40 (2.34)
High	3.33 (0.42)	0.94 (0.26)	7.28 (0.65)	6.87 (0.76)
I look forward to the future				
Low	8.98 (1.81)	4.90 (1.23)	13.66 (1.72)	13.90 (2.18)
High	2.96 (0.46)	0.91 (0.28)	7.53 (0.62)	7.21 (0.71)
I feel good about myself				
Low	9.24 (1.82)	7.61 (1.91)	13.12 (1.75)	12.83 (2.10)
High	3.20 (0.45)	0.73 (0.22)	7.80 (0.62)	7.57 (0.76)
I am satisfied with the way my life is now				
Low	9.04 (1.85)	4.79 (1.43)	12.53 (1.77)	14.79 (2.10)
High	3.20 (0.45)	1.09 (0.30)	7.77 (0.64)	7.08 (0.71)
I feel alone in my life				
Low	4.65 (1.11)	2.71 (1.06)	9.39 (1.15)	10.78 (1.30)
High	3.76 (0.54)	1.30 (0.37)	8.26 (0.73)	7.55 (0.88)
Mean quality of life score				
Low	10.94 (2.31)	6.77 (1.76)	13.91 (1.63)	15.11 (1.95)
High	2.92 (0.44)	0.80 (0.23)	7.46 (0.62)	6.95 (0.77)

[a] Values are percentages of light or frequent smokers (SE)

[b] Low quality of life: 1 SD below the sample mean; High quality of life: 1 SD equal or over the sample mean

Multinomial regression models of smoking intensity

In the fully adjusted multinomial regression models (Table 4), weight status and weight control behaviors were not significantly associated with smoking among boys. Among girls, weight status was not significantly associated with smoking. Trying to stay the same weight relative to having no weight control behavior was associated with lower odds of light smoking versus no smoking for younger girls (OR = 0.25; 95 % CI = 0.08, 0.84), whereas trying to lose weight relative to having no weight control behavior was associated with higher odds of light smoking versus no smoking for older girls (OR = 1.73; 95 % CI = 1.11, 2.70). For both girls and boys, low mean quality of life was associated with higher odds of light and frequent smoking compared to no smoking ($P < 0.001$).

Table 3 Percentage of respondents smoking cigarettes during the past 30 days, 2010 Washington State Healthy Youth Survey (girls)[a]

	Girls aged ≤14 years		Girls aged ≥15 years	
	Light smoking	Frequent smoking	Light smoking	Frequent smoking
Race/ethnicity	$n = 1{,}763$		$n = 2{,}790$	
Non-Hispanic White	5.54 (0.83)	2.20 (0.50)	8.03 (0.77)	6.88 (0.82)
Non-Hispanic Black	2.78 (2.02)	0 (0)	8.89 (2.86)	5.56 (2.29)
Hispanic	8.74 (2.16)	0.48 (0.49)	9.14 (1.56)	1.88 (0.61)
Other	4.35 (0.93)	1.70 (0.66)	5.98 (0.92)	6.72 (1.06)
Maternal education	$n = 1{,}385$		$n = 2{,}522$	
≤12 years	7.52 (1.06)	2.63 (1.05)	9.53 (0.87)	10.05 (1.25)
>12 years	4.34 (0.84)	1.41 (0.44)	6.42 (0.66)	4.05 (0.61)
Weight status	$n = 1{,}778$		$n = 2{,}802$	
Normal	4.69 (0.65)	1.56 (0.45)	7.12 (0.63)	5.82 (0.66)
Overweight	7.33 (1.51)	2.56 (0.94)	10.16 (1.46)	6.42 (1.32)
Obese	8.08 (1.99)	2.48 (1.23)	9.74 (2.03)	8.72 (2.17)
Weight control behavior	$n = 1{,}778$		$n = 2{,}802$	
None	4.83 (1.17)	1.21 (0.50)	4.96 (0.95)	6.12 (1.17)
Trying to lose weight	7.12 (0.95)	2.44 (0.73)	9.33 (0.74)	6.62 (0.71)
Trying to gain weight	6.78 (3.26)	5.08 (2.77)	10.00 (3.19)	11.25 (3.45)
Trying to stay the same weight	1.37 (0.71)	0.27 (0.27)	5.65 (1.04)	3.77 (0.83)
Quality of life[b]	$n = 1{,}778$		$n = 2{,}802$	
I feel I am getting along with my parents or guardians				
Low	12.42 (1.96)	5.41 (1.54)	13.65 (1.52)	10.87 (1.65)
High	3.89 (0.58)	1.02 (0.30)	6.52 (0.53)	5.14 (0.56)
I look forward to the future				
Low	11.27 (1.81)	4.22 (1.41)	14.54 (1.93)	13.95 (1.98)
High	4.28 (0.58)	1.34 (0.36)	6.78 (0.54)	5.03 (0.56)
I feel good about myself				
Low	12.01 (1.80)	6.01 (1.49)	13.20 (1.52)	11.04 (1.46)
High	3.88 (0.57)	0.83 (0.28)	6.62 (0.57)	5.13 (0.64)
I am satisfied with the way my life is now				
Low	11.01 (1.98)	5.36 (1.42)	12.79 (1.62)	12.79 (1.82)
High	4.09 (0.61)	0.97 (0.29)	6.77 (0.57)	4.86 (0.60)
I feel alone in my life				
Low	7.88 (1.30)	3.70 (1.19)	11.11 (1.22)	8.26 (1.00)
High	4.66 (0.68)	1.24 (0.35)	6.65 (0.62)	5.43 (0.67)
Mean quality of life score				
Low	13.42 (1.72)	5.48 (1.37)	14.72 (1.71)	12.12 (1.63)
High	3.33 (0.54)	0.85 (0.28)	6.32 (0.55)	4.92 (0.58)

[a] Values are percentages of light or frequent smokers (SE)

[b] Low quality of life: 1 SD below the sample mean; High quality of life: 1 SD equal or over the sample mean

When the five individual quality of life item scores was included in the adjusted multinomial regressions rather than the mean score (data not shown in tables), the findings for weight status and weight control behaviors remained robust. Compared with no weight control behavior, trying to stay the same weight was associated with lower odds of light versus no smoking for younger girls (OR = 0.25; 95 % CI = 0.07, 0.84), and trying to lose weight was associated with higher odds of light versus no smoking for older girls (OR = 1.76; 95 % CI = 1.13, 2.74).

Low scores for the item "I feel good about myself" were associated with higher odds of frequent smoking (OR = 6.92; 95 % CI = 2.46, 19.42) compared to no smoking for younger boys. For older boys, low scores for the item "I feel I am getting along with my parents or guardians" were associated with higher odds of light

Table 4 Adjusted associations between smoking and weight status, weight control behavior, and quality of life, 2010 Washington State Healthy Youth Survey ($n = 8,702$)[a]

	≤14 years		≥15 years	
	Light smoking	Frequent smoking	Light smoking	Frequent smoking
Boys				
Weight status				
Normal	1.00	1.00	1.00	1.00
Overweight	1.44 (0.75–2.77)	0.83 (0.25–2.75)	1.01 (0.67–1.52)	1.25 (0.82–1.91)
Obese	0.84 (0.31–2.30)	2.25 (0.63–8.06)	1.36 (0.78–2.36)	1.01 (0.56–1.83)
Weight control behavior				
None	1.00	1.00	1.00	1.00
Trying to lose weight	1.12 (0.60–2.10)	0.72 (0.23–2.29)	1.15 (0.78–1.69)	0.97 (0.66–1.42)
Trying to gain weight	1.70 (0.82–3.52)	1.35 (0.31–5.97)	1.31 (0.87–1.98)	0.82 (0.56–1.20)
Trying to stay the same weight	1.30 (0.61–2.79)	1.55 (0.48–5.02)	1.24 (0.84–1.81)	0.80 (0.53–1.21)
Mean quality of life score[b]				
High	1.00	1.00	1.00	1.00
Low	4.50 (2.60–7.80)***	9.03 (4.48–18.23)***	2.24 (1.64–3.05)***	2.47 (1.76–3.47)***
Girls				
Weight status				
Normal	1.00	1.00	1.00	1.00
Overweight	1.24 (0.74–2.05)	1.54 (0.63–3.73)	1.20 (0.79–1.81)	1.04 (0.64–1.68)
Obese	1.23 (0.65–2.35)	1.15 (0.36–3.69)	1.05 (0.60–1.84)	1.28 (0.69–2.35)
Weight control behavior				
None	1.00	1.00	1.00	1.00
Trying to lose weight	1.03 (0.56–1.89)	1.31 (0.38–4.51)	1.73 (1.11–2.70)*	0.97 (0.63–1.48)
Trying to gain weight	1.14 (0.34–3.80)	3.34 (0.61–18.29)	1.83 (0.82–4.06)	1.85 (0.89–3.86)
Trying to stay the same weight	0.25 (0.08–0.84)*	0.20 (0.02–1.77)	1.14 (0.73–1.80)	0.60 (0.35–1.03)
Mean quality of life score[b]				
High	1.00	1.00	1.00	1.00
Low	4.09 (2.66–6.29)***	6.49 (3.35–12.55)***	2.52 (1.83–3.48)***	2.52 (1.78–3.58)***

[a] Values are odds ratio (95 % confidence interval). Adolescent boys, ≤14 years, $n = 1,561$ and ≥15 years, $n = 2,561$; Adolescent girls, ≤14 years, $n = 1,778$ and ≥15 years, $n = 2,802$. All estimates were adjusted for race/ethnicity and maternal education. Odds ratios are versus no smoking

[b] Low quality of life: 1 SD below the sample mean; High quality of life: 1 SD equal or over the sample mean

* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$

(OR = 2.25; 95 % CI = 1.54, 3.28) or frequent smoking (OR = 2.34; 95 % CI = 1.47, 3.72) compared to no smoking. Low scores for the item "I look forward to the future" were associated with higher odds of light smoking (OR = 1.64; 95 % CI = 1.10, 2.45) compared to no smoking. Low quality of life scores for the items "I am satisfied with the way my life is now" and "I feel alone in my life" were not significantly associated with smoking for boys.

For younger girls, low scores for the item "I feel I am getting along with my parents or guardians" were associated with higher odds of light smoking (OR = 2.23; 95 % CI = 1.25, 3.98) or frequent smoking (OR = 2.41; 95 % CI = 1.13, 5.15) compared to no smoking. Low scores for the item "I feel good about myself" were associated with higher odds of frequent smoking (OR = 3.29; 95 % CI = 1.33, 8.13) compared to no smoking. For older girls, low scores for the item "I feel I am getting along with my parents or guardians" were associated with higher odds of light smoking (OR = 1.68; 95 % CI = 1.22, 2.31) compared to no smoking. Low scores for the item "I look forward to the future" were associated with higher odds of light (OR = 1.78; 95 % CI = 1.25, 2.52) or frequent smoking (OR = 2.17; 95 % CI = 1.43, 3.29) compared to no smoking. Low scores for the item "I feel alone in my life" were associated with higher odds of light smoking (OR = 1.45; 95 % CI = 1.03, 2.02) compared to no smoking. Low quality of life scores for the item "I am satisfied with the way my life is now" was not associated with smoking for girls.

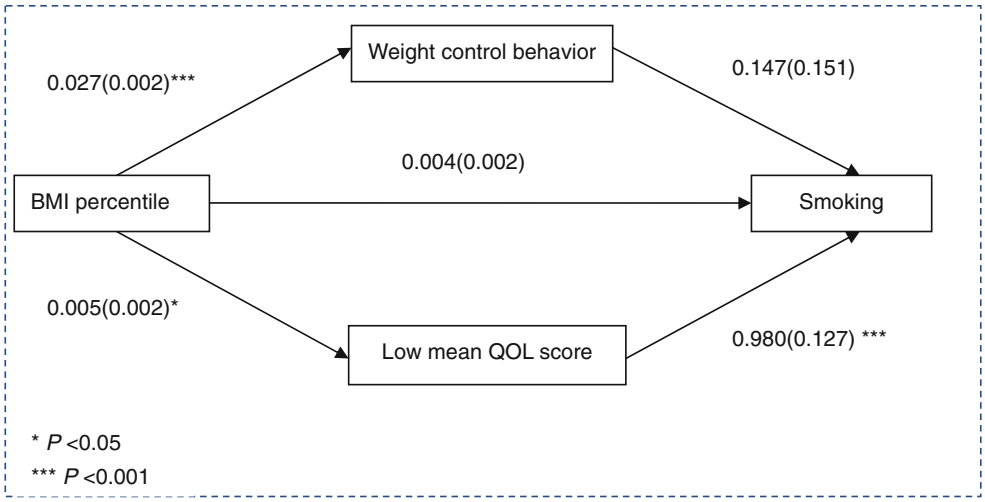

Fig. 1 Effect of BMI percentile on smoking mediated by weight control behavior and mean quality of life score with unstandardized coefficients (standard errors)

Weight control behavior and QOL as potential mediators

Applying the method of Baron and Kenney [30], the criteria for mediation were only met among older girls. BMI percentile was significantly associated with weight control behavior and quality of life, BMI percentile was significantly associated with smoking (coefficient = 0.005, $P = 0.017$), and quality of life was significantly associated with smoking controlled by BMI percentile. The mediation model with unstandardized coefficients and standard errors is summarized in Fig. 1. The total indirect effect of weight control behavior and quality of life combined was significant with 30.3 % of the effect of BMI percentile on smoking mediated. The direct effect of BMI percentile on smoking became non-significant after weight control behavior and quality of life were included in the model. When the five individual quality of life item scores was included together in a multiple mediation model rather than the mean score (data not shown in tables), the findings for the total indirect effect of weight control behavior and quality of life combined remained robust, with 40.0 % of the effect of BMI percentile on smoking mediated among older girls.

Discussion

This study is unique in its examination of age- and sex-specific associations between weight status and different intensities of smoking. We contribute to existing work by including a large sample of both males and females in an expanded age range and by testing the role of QOL and weight control behavior as potential mediators of associations between weight status and smoking among adolescents. We found evidence that weight control behavior and quality of life mediate some, but not all, of the association between BMI percentile and smoking among older girls.

Quality of life is a broad and global concept affected in complex ways by an individual's physical health, psychological state, level of independence, social relationships, and relationships to salient attributes of the environment [20]. Overweight among youth is associated with lower health-related quality of life [33]. The hypothesis that overweight adolescents with low QOL may cope by cigarette smoking is plausible. Low mean quality of life was associated with higher odds of light and frequent smoking compared to no smoking for both girls and boys. Low scores for four individual items ("I feel I am getting along with my parents or guardians", "I look forward to the future", "I feel good about myself", "I feel alone in my life") were associated with smoking for boys or girls. Similar results were found in another study applying the same four YQOL-S items, engagers scored significantly lower than either abstainers or experimenters for all four items, and experimenters scored significantly lower than abstainers for the items "I feel I am getting along with my parents or guardians" and "I feel good about myself" [21].

When QOL and weight control behaviors were controlled, no significant associations between weight status and smoking for boys or girls were found. In simplified mediation models, BMI percentile was also not significant in age- and sex-specific subgroups. Our results are consistent with prior work assessing weight status and smoking relationships with controls for psychological correlates such as low self-esteem and negative mood [14]. However,

other work has shown that obese girls are more likely to be smokers than their normal-weight peers after adjustment for QOL and weight control [23]. The differences in the findings between the two studies may be explained by differences in the measure of QOL or differences in the other covariates controlled in the models. We examined the indirect effect of potential mediators such as weight control behavior and quality of life in associations between weight status and smoking, which has not been reported in previous study. The total indirect effect of weight control behavior and quality of life combined was significant with 30.3 % (using mean QOL score) or 40.0 % (using individual QOL item scores) of the effect of BMI percentile on smoking mediated. Future research is recommended to explore the influence of QOL measured by generic and weight-specific instruments which capture different aspects of youth's perceptions to better understand associations between weight status and smoking.

Multiple dimensions of weight concerns may be salient in relation to smoking, including perceived weight, general weight concerns (e.g., worry about weight gain or the belief that smoking helps control weight), dieting behaviors, and restrained eating [34]. Dieting or weight-loss behaviors among female adolescents have the strongest positive association with adolescent smoking [14]. Girls may place more value on appearance and thinness than boys and may have increasing weight concerns along with concerns about dating and appearance. Consistent with prior work, our study found that trying to lose weight relative to having no weight control behavior was associated with increased odds of light smoking versus no smoking for older girls [14]. Both smoking and dieting behaviors may be part of a cluster of risk behaviors in youth [35]. Youth risk behaviors cluster because they serve similar functions for youth, occur within common social settings, and share similar underlying factors [36]. Smokers engage in less healthy dietary behaviors and more unhealthy weight control methods than nonsmokers [37], and smoking susceptibility is negatively associated with being highly active [38]. Trying to stay the same weight, which may reflect healthy weight control methods, was associated with lower odds of light smoking for younger girls in our study; however, in younger adolescents, the role of parental influence on health-related behaviors must also be considered.

Associations between smoking, weight status and weight concerns may differ by smoking stage [14]. However, few studies employ identical measures of smoking behaviors which limits the comparability of the findings. For instance, the definition of regular smoking may be based on the number of cigarettes smoked, the number of smoking days in a given time period or a combination of both. In our study, weight status was not associated with frequent smoking defined as at least 10 days smoking during the past 30 days, whereas this association was significant in other work where frequent smoking was defined as having smoked at least three times during the last 30 days [23]. This discrepancy highlights the need for consistency in measures of smoking in future studies.

The strengths of this study include the large sample representative of Washington State youth; examination of age- and sex-specific associations between weight status and intensity of smoking; and tests for indirect effects of weight control behavior and quality of life as potential mediators. Several limitations should also be considered. First, the data were cross sectional and cannot be used to infer causation of observed associations. Second, although self-reported values of height, weight, and BMI are highly correlated with their measured values, on average, students over-report their height and under-report their weight with leading to underestimation of the prevalence of overweight in adolescent populations [39]. Third, only one survey item was available to measure weight concerns in the HYS questionnaire; therefore, other weight concern dimensions could not be addressed. Finally, we used maternal education as a proxy measure for SES, which is insufficient to adequately capture broader facets of SES such as income and occupation.

Conclusion

Our findings suggest that low quality of life was associated with higher odds of light and frequent smoking compared to no smoking for both boys and girls. Trying to stay the same weight relative to having no weight control behavior was associated with lower odds of light smoking versus no smoking for younger girls, whereas trying to lose weight relative to having no weight control behavior was associated with increased odds of light smoking versus no smoking for older girls. Weight control behavior and quality of life appear to mediate some, but not all, of the association between BMI percentile and smoking among older girls. Understanding how weight status, weight concerns, and QOL are associated with smoking is necessary to develop appropriate interventions targeted at weight management and smoking prevention among adolescents. Future research should highlight objective weight status measures, generic and weight-specific QOL measures, multiple dimensions of weight concerns, associations with smoking stages, and longitudinal designs for causal inference.

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Conflict of interest The authors declare no conflict of interests.

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