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Stressful life events, gender and obesity: A prospective, population-based study of adolescents in British Columbia

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ABSTRACT

Objective: To determine whether stressful life events are related to levels of obesity in a group of ethnically diverse Canadian youth and the extent to which the relationship differs by gender.
Methods: This study of 905 adolescents (age 13–17 years) from a BC population-based cohort (BASUS) used self-reported data from Wave 5 (2011 fall) on stressful life events and socio-demographic factors and from Wave 6 (2012 spring) on weight and height. Multivariable logistic regression models conditioned on known confounders and used a cross-product term for effect modification by gender. Post-estimation analysis calculated gender-specific predicted mean probabilities of having obesity associated with greater frequency of stressful life events.
Results: Compared to young men reporting no stressful life events in the previous year, young men reporting one event were nearly 50% more likely to have obesity at 6-month follow-up (OR 1.47 [95% CI: 0.63, 3.41]) and those reporting multiple stressful life events were twice as likely to have obesity at 6-month follow-up (OR 2.07 [95% CI: 0.79–5.43]). Only young women reporting multiple events showed a higher likelihood of having obesity at the end of the study (OR 1.32 [95% CI: 0.41–4.18]) than their counterparts reporting no life events.
Conclusions: Results suggest that the frequency of major life events may be an important social stressor associated with obesity in adolescents, particularly for young men. However, findings should be replicated in larger samples using measured anthropometry to inform future obesity prevention strategies.

1. Introduction

Adolescent obesity is a global health concern despite serious efforts towards its mitigation [1]. A third of young people in Canada have excess weight [2], which is a substantial public health challenge, as obesity is a strong risk factor for numerous chronic conditions [3,4], and 80% of adolescents with obesity have it in adulthood also [5]. Although weight gain is common during adolescence, stress-related weight gain is also likely to increase during this developmental period, as adolescents are particularly vulnerable to disturbances of the stress response pathways [6,7]. Understanding the role of social stressors such as adverse life events is critical to design effective obesity interventions for young people who are greatly need it, as shown in a recent Cochrane review [8].

Young people experience a unique period of developmental vulnerability so that major life events like social stressors can permanently impact their brain development as well as their metabolically relevant systems, which, in turn, could negatively affect proper physical functioning and emotional regulation during adulthood [9]. Unlike other age groups, young people are distinct insofar, as they are more vulnerable to the health impact of stress while also being more likely to have little control over the stressful life events that they experience [10]. The independent stressors

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reported by young people range in magnitude from more common everyday life events (25%) such as separating from a romantic partner or parental divorce to more extreme but less common life events (6.2%), including death of a parent or surviving a violent act [11]. By the age of 16 years, it is estimated that a quarter of young people will have experienced at least one high-magnitude stressor [11]. As compared to adults, young people will be more emotionally vulnerable to social stressors because their development-specific brain alterations mean they have higher basal levels of hypothalamic–pituitary–adrenal (HPA) activity and heightened biological stress reactivity [12]. Higher HPA activation and cortisol levels have known effects on central adiposity [13].

There is some evidence to show that adolescents' differential brain development is associated with greater responsiveness to emotion-related social cues and incentives, which occurs at the time when they have underdeveloped neurological pathways that are responsible for rational decision-making and resisting temptations [14]. In this development context, social stressors that induce changes to the brain in young people could have negative metabolic consequences by making them more susceptible to the hedonic effects of highly palatable foods (i.e. rich in sugar and fat) [15]. The consumption of energy-dense foods triggers the brain's reward pathway and becomes a reinforcing behaviour in the same way as that of drug use in young people, underpinned by the principles of reward and reinforcement [16]. It is also important to consider how stressful life events affect weight-related outcomes differently for young women and young men, given sex hormone differences in HPA activation and stress reactivity [17].

Thus, behavioural alterations that occur from physiological adaptations or from coping responses to stressful life events constitute another pathway to poor metabolic outcomes [18]. More specifically, social stressors could lead to young people not only eating poor-quality diets but also sitting more, exercising and sleeping less as well as consuming illegal substances such as tobacco and alcohol—all behaviours that have been associated with adiposity.

Indeed, sleep deprivation is associated with obesity, and the interaction between stressful life events and altered sleep patterns could create a potentially damaging nexus of negative metabolic effects [19]. Social stressors can induce changes to sleep–wake cycles that amplify the negative effects of development-specific sleep deprivation on satiety hormone (leptin) regulation [20] and emotional regulation [21] and thus lead to higher intakes of palatable, energy-dense foods and excess weight increase [22]. Such behavioural changes and lifestyle habits formed during adolescence may endure into adulthood due to the underlying physiological development [23] and could help explain why adolescent obesity predicts adult risk more than the risk in young age groups [5].

Again, the impact of social stressors on obesity prevalence may differ between young women and young men because sex chromosomes are known to regulate habit formation [24], and both the prevalence of sleep problems [25] and the amount of sleep deprivation required to affect metabolic outcomes is greater in young women than in young men [26]. However, few studies apply gender-based analysis to address the extent to which women and men differ in their exposures to stressful life events is associated with differential vulnerability to poor health [27], and current evidence on the metabolic effects of stressful life events is limited to cross-sectional designs and populations of children or adults only [28,29]. This study aimed to investigate the relationship between stressful life events and obesity in a population-based cohort of young people using a gender perspective [30]. In applying a gender perspective similar to that in our previous work [31], we hypothesized that greater levels of stressful life events would be associated with higher obesity at follow-up and that the associations would show gender-specific patterning.

2. Subjects and methods

2.1. Study population

This study used data from participants in the population-based *British Columbia Adolescent Substance Use Survey (BASUS)* cohort study that comprised 3170 students aged 13–18 years from 86 secondary schools in British Columbia, Canada [31], who completed biannual online surveys from October 2009 (Wave 1) to December 2012 (Wave 7). We used self-reported data from Wave 5 (2011 fall) on stressful life events (n = 1543), sleep and wake times (n = 1469) and socio-demographics (n = 973) and from Wave 6 (2012 spring) on weight and height (n = 1575). Written informed consent was obtained from all volunteer students following school district procedures; ethics approval for the BASUS study (no. H08–02841) was given by the Behavioural Research Ethics Board of the University of British Columbia [31,32].

2.2. Measures

2.2.1. Stressful life events

We used the junior high life experiences survey [33] listing 13 events specific to assess exposure to stressful life events, similar to another work [34]. The survey asks participants to report retrospectively over 12 months whether or not they experienced any of the following events: *family moved to new house, close friend committed suicide, family member committed suicide, parents separated/divorced, one parent died, participant found out about their being adopted, first-time job loss, victim of violence, broke up with girlfriend/boyfriend, first intercourse, had sexually transmitted disease, expelled from school, first-time police involvement* [33,34]. Participants reported whether or not they experienced a given event in the previous 12 months. The total number of events was calculated, and students were classified into a three-level categorical variable for their exposure to zero, one and multiple (≥2) recent stressful life events.

2.2.2. Obesity status

We measured obesity status at study follow-up based on body mass index (BMI), which we calculated from self-reported data on height and weight. Gender- and age-specific thresholds for BMI were used to classify participants as either having obesity (>97th percentile) or not (3rd to 97th percentile), based on the Dietitians of Canada WHO Growth Charts for Canada [35]. We therefore excluded participants with BMI-for-age percentiles falling below the normal weight category (n = 43) and those with BMI-for-age values exceeding the range in the charts (n = 18).

2.2.3. Covariates

Concurrent socio-demographic variables included ethnicity (Caucasian [reference], Asian, Aboriginal and Other [Latino, Black, and others]), maternal education (university or higher [reference], some vocation or college, secondary school and below secondary school) and pubertal stage (post-pubertal (reference), late pubertal, mid-pubertal, early pubertal and pre-pubertal) [31]. As chronological age is a less sensitive measure of development-related weight change [36], we used pubertal stage, which we derived from sex-specific questions related to pubertal development following an established method [37].

2.3. Statistical analysis

Descriptive statistics summarised baseline sociodemographic characteristics and obesity across levels of stressful life events. Chi-square test was used to assess the significance of gender differences in the proportion reporting different levels of stressful life events. Our main analysis had the *a priori* strategy to examine the gender-specific relationship between stressful life events and obesity; thus, we performed a series of logistic regression models including an interaction term between the exposure and the variable for self-reported male/female and sequentially adjusted for pubertal stage, ethnicity and maternal education. The final sample analyzed was 905 and appeared similar to the full cohort in terms of baseline measures of sociodemographic characteristics and health outcomes (Supplementary Table 1).

Sensitivity analyses tested the robustness of the main findings to the use of alternative socioeconomic indicator, as family income as perceived relative to peers may be more reliably reported than mother's education level. Thus, models were separately adjusted for being far above average/slightly average (reference), slightly above average, average, slightly below average and slightly below average/far below average (n = 943) [31]. Separate models also tested for additional confounding by depressive symptomology (CESD score ≥ 24) [38] (n = 796). All statistical analyses were conducted using Stata 14.1 (StataCorp. 2013). We report our results using odds ratios (OR) and 95% confidence intervals (95% CI).

3. Results

Our sample of adolescents (13–17 years) had an average age of 14.8 years (SD 0.7), with 58% women and 51% white ethnicity. Most (65%) rated their health as very good/excellent, many reported having a university-educated mother (41%) and a relatively above-average family income (44%) and few (7%) were classified as having obesity at follow-up. Notably, a higher proportion of young men (11%) than young women (5%) had obesity at follow-up. Nearly a third (n = 297) of young people reported experiencing one or more stressful life events: 20% reported one recent event and 11% reported multiple recent events. A higher proportion of young women reported one and multiple stressful life events, which showed significant difference from the proportions of young men reporting exposure to stressful life events (P = .005). The most common stressful life events for young people in BC were moving to a new home and splitting up from a boyfriend or girlfriend (Table 1).

Table 2 shows the distribution of social and health characteristics across levels of stressful life events. Exposure to multiple stressful life events was more prevalent among females than males, post-pubertal adolescents, those with depression, lower self-rated health and lower socio-economic status. There was a higher prevalence of obesity at follow-up among participants reporting multiple stressful life events (11%) than those not exposed (6%) (see Table 2).

3.1. Gender differences in the relationship between stressful life events and obesity

Multivariable-adjusted regression models showed a monotonic association between greater frequency of stressful life events and obesity at study follow-up in young men only (Table 3, Model D). Compared to young men reporting no stressful life events, those reporting one event were 47% more likely to have obesity (OR 1.47 [95% CI: 0.63–3.41]) and those reporting multiple events two times more likely to have obesity (2.07 [0.79–5.43]). Only young women reporting multiple stressful life events showed higher odds of subsequent obesity (1.32 [0.41–4.18]) than those reporting none. Findings were attenuated for young men and women reporting multiple events when maternal education was replaced with household income (1.69 [0.28–4.35] and 1.07 [0.92–3.90], respectively) but were amplified when additionally adjusting for depression (2.54 [0.90–7.18] and 1.55 [0.44–5.40], respectively).

4. Discussion

This population-based study of young people aged 13–17 years found a nonsignificant association between two or more stressful life events and obesity status a year later, independent of known confounders. The pattern of association appeared monotonic for young men only. However, findings need to be replicated in a larger sample with more prevalent and clinically measured obesity to provide stronger empirical support for our initial hypotheses that exposure to greater amount of stressful life events would be linked to higher obesity levels in a gender-specific manner.

Table 1
Frequency of self-reported stressful life events among young people in the BASUS cohort.

	Total, n	Males, n	Females, n
None	1018	440	578
Move to new house	201	79	122
Split up with girlfriend/boyfriend	184	65	119
Parents divorced	79	27	52
First time having intercourse	72	24	48
Involved with police	65	31	34
Victim of violence	61	25	36
Suicide of friend	38	11	27
Lost job	31	12	19
Suicide of family	17	6	11
Found out you have an STD	15	6	9
Expelled from school	15	7	8
Death of a parent	14	7	7
First told you are adopted	7	5	2

Table 2
Sociodemographic and health characteristics of young people in the BASUS cohort across levels of stressful life events.

	Mean (SD) Age	Female	Highest maternal education[a]	High family income[b]	White ethnicity	Depressed[‡]	Excellent/very good health	Post-pubertal stage	Obesity status[§]
Stressful Life Events									
None (n = 609)	14.7 (0.7)	57%	45%	20%	48%	12%	70%	13%	6%
One (n = 196)	14.8 (0.6)	65%	48%	14%	61%	15%	66%	18%	8%
Two or more (n = 100)	15.0 (0.7)	63%	42%	17%	55%	47%	59%	21%	11%

BMI, body mass index (kg/m^2). Measurement time points were age, gender, ethnicity, maternal education, family income, depression and general health (Fall 2011); height and weight (2012 spring). [a] University or higher. [b] far above average or slightly above average relative to peers. [c] Depression score ≥24, assessed using Centre for Epidemiologic Studies Depression Scale. [§] BMI >97th percentile based on age- and gender-specific WHO growth charts.

Table 3
Odds ratios of obesity at follow-up associated with recent stressful life events in young women and young men in the BASUS cohort study.

	Young Women							
	Model A		Model B		Model C		Model D	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Stressful life events								
None	1.00		1.00		1.00		1.00	
One	1.27	.54, 2.99	.80	.29, 2.23	.79	.28, 2.21	.88	.31, 2.48
Two or more	2.16	.82, 5.68	2.13	.80, 5.70	1.62	.56, 4.69	1.32	.41, 4.18
	Young Men							
Stressful life events								
None	1.00		1.00		1.00		1.00	
One	1.44	.67, 3.09	1.31	.59, 2.92	1.31	.58, 2.95	1.47	.63, 3.41
Two or more	1.80	.74, 4.38	1.95	.78, 4.89	1.79	.70, 4.56	2.07	.79, 5.43

Gender-specific odds ratios (95% CI) obtained by multivariable linear regression analysis using an interaction term between sex and stressful life events (Model A, n = 1117) and adjusting for pubertal stage (Model B, n = 908), ethnicity (Model C, n = 975), and mother's education (n = 905).

4.1. Relevance to previous work

Overall, review evidence of longitudinal studies indicates that stressful life events are positively associated with obesity in young and adult populations [39,40]. Our results pointed to similar results, although not statistically significant. We also found potential gender differences, as higher odds of obesity were seen only in young women reporting two or more events but was monotonically patterned in young men. In adults, the prospective association seems to differ by gender whereby men have a higher obesity risk from stressful life events than women [40]. By contrast, cross-sectional evidence from two large epidemiological studies with U.S. adults reported female-specific effects of stressful life events on BMI [41,42]. Notably, Barry and Petry (2008) observed a strong positive association only in women when they examined exposure over the previous year to at least 12 stressful life events [42], which is a higher threshold than this study used. Overall estimates in children indicate that greater exposure to stressful life events are associated with a 12% greater likelihood of overweight status (OR 1.12) [43], and this association shows some gender differences in young children [44]. It is difficult to directly compare our results with those of previous works, as the literature uses heterogeneous nomenclature and operationalization of both stressful life events and obesity status, lacks a focus on this vulnerable age group of mid-to late-puberty and is silent on potential gender differences.

Several potential mechanisms could explain our finding of a relationship between increasing stressful life events and greater odds of having obesity, including physiological and behavioural responses. Chronic stress is known to increase overall activation of the HPA axis which can negatively affect hormonal regulation of metabolic activities. In particular, elevated cortisol levels in the body are associated with increased leptin levels and central adiposity [13]. Moreover, this disruption to leptin levels can lead to an inhibited sense of satiety, which, in turn, increases food consumption [13]. Concomitant with these physiological responses, stressful life events can lead to unhealthy behavioural responses. Poor coping mechanisms for stressful life events can further contribute to obesity risk through psychosocial effects that increase sedentary behaviour [45] and higher energy intake [46] and reduce physical activity [47].

The observed monotonic relationship between stressful life events and obesity in the short term among adolescent males could be explained by a combination of metabolic dysregulation and unhealthy behaviours that have known sex- and gender-based differences. Studies show that young males have a higher tendency for cortisol and autonomic nervous system reactivity than young females when exposed to stress; these works also find that the sex-based difference in HPA response patterns in mid-adolescence is similar to those found in adulthood [17]. Notably, female sex hormone cycles exert modulating effects on HPA responsiveness to perceived stress [48], with the post-ovulation luteal phase dampening the magnitude of other circadian rhythms such as cortisol [49]. In addition, there may be gender-based differences that explain the null association in young women. It is possible that a higher number of stressful life events are required to show negative influences on their weight given that women typically experience a higher burden of certain high-magnitude events and their negative consequences. In Canada, for example, the likelihood that women over the age of 15 years will be sexually victimized 11 times greater than that for men or stalked 3 times higher than men [50]. Alternatively, young women's social roles and norms mean they tend to have a bigger and wider social network that is a potential support system for coping with stressful life events and may mitigate the negative metabolic consequences of recent stressful life events. Other gender-specific norms about overeating behaviour and thin body ideals could also explain why stressful life events were not associated with obesity in young women.

4.2. Methodological considerations

Recall or social desirability bias could affect our self-reported exposures and outcomes [31,51]. Nevertheless, experiences of specific life events are important exposures to investigate, which provide concrete targets for intervention compared to global perceptions of psychological stress that are typically studied [39,40,43]. While social desirability bias in self-reported height and weight underestimates true obesity prevalence in a population, questions about the contextual influences of obesity risk can be answered by analyzing participants' relative rank in weight status based on self-reported BMI. Results may be biased by measurement error in the limited range of pre-specified response options and categories constructed for the exposure variables. This study may also be limited by bias from residual confounding from unmeasured factors such as young women's parity status, which could affect the outcome, but was not collected in the BASUS study.

Missing data predominantly on covariables may have introduced selection bias in our study, although our analyzed sample appeared to be representative of the full cohort apart from a slightly higher proportion of young men from high-income families and young women with university-educated mothers. Nevertheless, loss of sample size likely limited the power to detect a statistically significant result. Finally, our measure of stressful life events did not include assessment of event severity, which varied across the different types listed and may lead to differential gender-specific effects on obesity risk.

Notwithstanding these limitations, a key strength of our study is the population-based cohort that is representative of the broader adolescent population in Canada's west coast [52], and inclusion of ethnicity, pubertal stage and socioeconomic status as known confounders. Importantly, this work advances the evidence base in several ways. First, we examined independent stressful life events rather than a generic measure of perceived psychological stress, and thereby provide novel evidence on distinct risk factors that serve as direct targets for future interventions. Second, we focused on young people aged 13–17 years who have a unique developmental period putting them at particularly high risk of negative metabolic consequences from major life events. Third, we contributed a critical gender perspective on the relationship and demonstrated a differential patterning of the relationship between stressful life events and obesity in this age group.

5. Conclusion

Healthy young people in BC reporting multiple stressful life events were more likely to have obesity in the short term, more so for young men than young women. Findings add to previous work supporting the need to consider addressing young people's experiences of stressful life events in future obesity prevention strategies. Additional gender-sensitive health research should investigate the behavioural and biological mechanisms linking stressful life events with obesity risk.

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Disclosure

We declare no conflicts of interest.

Ethical statement

All volunteers gave written informed consent following school district procedures, and the study was approved by Behavioural Research Ethics Board of the University of British Columbia (No. H08−02841).

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The authors wish to thank the BASUS cohort participants for their contribution. Data from the BASUS Study cannot be deposited publicly due to ethics and consent requirements of the sensitive information from this vulnerable age group. Data requests can be made directly to the BASUS study team (www.basus.ca).

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijpam.2019.03.001.

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