BMJ Open

Gender, stressful life events and interactions with sleep: a systematic review of determinants of adiposity in young people

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To cite: Conklin AI, Guo SXR, Tam ACT, *et al*. Gender, stressful life events and interactions with sleep: a systematic review of determinants of adiposity in young people. *BMJ Open* 2018;**8**:e019982. doi:10.1136/bmjopen-2017-019982

► Prepublication history and additional material for this paper are available online. To view these files, please visit the journal online (http://dx.doi.org/10.1136/bmjopen-2017-019982).

Received 12 October 2017
Revised 10 April 2018
Accepted 8 June 2018

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ABSTRACT

Objectives Overweight and obesity among young people are high and rising. Social stressors and sleep are independently associated with obesity, but are rarely studied together or examined for gender-specific effects. The literature regarding adolescent populations is especially lacking. This review assesses whether experiencing stressful life events results in greater adiposity in young women and young men compared with those who do not experience stressful life events, and whether the relationship is modified by sleep problems.

Design We systematically searched six bibliometric databases (Web of Science, Embase Ovid, PsycINFO, CINHAL, PubMed, ProQuest Dissertations) supplemented by hand searches. Longitudinal prospective studies or reviews were eligible for inclusion when they examined gender-specific changes in adiposity in young adults (age 13–18 years) as a function of stressful life event alone or in combination with sleep problems.

Results We found one study eligible for inclusion reporting mixed impact of stressful life events on body mass index (BMI) between genders. The study assessed specific life events and showed significantly lower BMI at follow-up among young men who experienced a residence change, but significantly higher BMI among young women who experienced setting up a family and who reported internal locus of control.

Conclusions Despite ample research on social stressors or sleep problems and weight, we still know little about the role of stressful life events, or combined effects with sleep, on obesity risk in adolescents from a gender perspective. Existing evidence suggests specific life events affect weight differently between the genders. Robust, high-quality longitudinal studies to decipher this dual burden on obesity during adolescence should be prioritised, as firm conclusions remain elusive.

Strengths and limitations of this study

- ► Stringent inclusion criteria of longitudinal study design, gender-specific estimates and short age range may have limited results.
- ► Comprehensive systematic literature search covered six databases from multiple health disciplines using broad search terms with no publication date limitations.
- ► Searches conducted by two independent reviewers to look at the adolescent population biologically marked by puberty, and applied a gender perspective.

INTRODUCTION

Globally, there is a high and growing burden of excess body weight in children and adolescents, particularly in countries where Western diets are routinely consumed.[1 2] In Canada, recent statistics indicate that around 20% of children and young people are overweight and nearly 12% are obese. Carrying extra weight is linked to numerous chronic conditions and clinical complications, with substantial negative effects on both physical and psychological health.[2 3] One of the greatest concerns about excess weight among young people is that obesity tracks into adulthood, with 80% of obese adolescents retaining their obese status in adulthood.[1 4] Although adolescence is commonly marked by increases in weight, young people are uniquely vulnerable to perturbations of the stress response pathways which may contribute to the increase in stress-related weight gain.[5 6] As this developmental period is marked by major socioemotional transitions between childhood and adulthood, social stressors that trigger stress responses may be an important determinant of obesity risk in young people.

Adolescents are more likely than other age groups to experience stressful life events over which they have little control, while also being more vulnerable to the health impact of the stress response. The types of independent stressors reported among young people range in magnitude and prevalence from low-magnitude events (25%), such as ending a relationship, to highly traumatic events

(6.2%), such as bereavement or surviving sexual assault.[7] Important developmental changes to the brain that occur only during this period make young people more emotionally susceptible to social stressors due to higher basal levels of hypothalamic–pituitary–adrenal (HPA) activity, and heightened stress reactivity, compared with adults.[8] Furthermore, research on the differential brain development of adolescents indicates they become more responsive to incentives and socioemotional contexts at a time when neural mechanisms for executive functioning and impulse inhibition have yet to fully develop.[9] Thus, alterations of the adolescent brain by stressor-induced responses can result in young people becoming more readily addicted to highly rewarding foods.[10] Notably, the principles of reward and reinforcement that apply to drug use in young people also apply to their consumption of energy-dense foods since both behaviours activate the same reward circuitry in the brain.[11]

In addition, concurrent changes in the circadian regulation of sleep have implications for adolescent behaviours and their greater vulnerability to the impact of stressors on weight gain. Sleeping phases are not only delayed during puberty,[12] but both sleep duration and sleep quality also appear to be reduced among young people.[13 14] Problems with sleep are reported by 41% of young people,[14] and are linked to changes in eating patterns and metabolic disorders in adults.[10] Leptin is a satiety hormone[15] that follows a circadian rhythm,[16] and may also serve as a metabolic gate permitting pubertal maturation.[5] The stress hormone, cortisol, also follows a circadian rhythm, and fluctuations in circulating cortisol are known to interact with both the sleep–wake cycle and leptin signalling.[17] Sleep deprivation alone makes the HPA axis hyperactive,[17] but disturbed sleep/wake cycles especially when induced by stressful life situations can also affect a person's leptin levels leading to greater consumption of more energy-dense foods and subsequent weight gain.[18] The independent and interaction effects of stressful life events and sleep problems on metabolic outcomes results in a vicious cycle.[19]

Compounding this complexity is the importance of gender differences in how stressful life events impact obesity risk in young people through biological or behavioural stress responses. Puberty triggers dramatic changes in gonadal hormone levels that also affect the HPA axis,[5 20] and stress reactivity is known to differ between adult women and men.[21] The effect of testosterone on the HPA axis appears to be inhibitory in males, and partly because of this, adult men tend to have lower basal stress levels and are less reactive to stress than women.[22] However, studies of adolescent women report mixed findings on whether they are physiologically more reactive to environmental stressors than young men.[23] Nevertheless, girls typically report more subjective negative effect for the same amount of physiological arousal than do boys.[24] Thus, adolescence is a period of unique vulnerable whereby stressful life events could have permanent effect on both brain development and metabolic systems, which may compromise emotional regulations and functioning in adult life. In addition, the impact of stressful life events on obesity risk in young people is likely to differ by gender.

This study systematically reviewed the prospective evidence from longitudinal studies with gender-specific data to determine whether exposure to stressful life events results in greater adiposity in young people aged 13–18 years, compared with those who do not experience stressful life events, and whether this relationship is modified by sleep problems. This extends current knowledge on the importance of psychobiological stress responses or sleep constraints, to determine the impact of lived experiences of stressful life events common among adolescents, and to decipher the possible combined effect with sleep problems on obesity risk from a gender perspective.

METHODS

Patient and public involvement

No patients or public were involved in this literature review.

Search and selection

Peer-reviewed literature was systematically searched using six bibliometric databases (Web of Science, Embase Ovid, PsycINFO, CINHAL, PubMed, ProQuest Dissertations) and supplemented with hand searches from retrieved full texts. We followed a common approach for systematic reviews as given by the Cochrane collaboration.[25] Since the Cochrane method for quality assessment (designed for appraising clinical practice) considers observational study evidence as low quality, we employed a modified version of the Effective Public Health Practice Project tool and the Newcastle-Ottawa scale—both identified by the UK's Health Technology Assessment Programme as 'best' tools for evaluating observational studies.[26] We used Medical Subject Heading terms, supplemented by free-text thesaurus terms, with Boolean operators for 'stressful life events', 'sleep', 'body weight' and 'adolescents' (table 1). No limitations were imposed on publication date, country or language. Age group was restricted

Table 1 Search terms used in six bibliometric databases to identify potentially eligible records for inclusion

Concept	Search terms ('/' indicating 'OR')
Weight	Body weight/body mass index/adiposity/anthropometry/body image/BMI/body adiposity index
Adolescents	Adolescen*/youth*/teen*/high school/high school student
Stressful life events	Stress, Psychological/life change event*/life stress/life event*/adverse life event*/negative life event*/emotional stress/emotional distress/social stress
Sleep	Sleep/night sleep/sleep quality/sleep time/sleep duration

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to predetermined categories in CINAHL (13–18 years) and PsycINFO (13–17 years) databases. Searches were performed separately by SXRG and ACTT during May 2017.

Inclusion and exclusion criteria

Our review included eligible longitudinal studies, reviews and dissertations, examining weight gain in young people as a function of stressful life events, combined with sleep problems as a potential effect modifier. Studies were considered when participants or subgroup analyses involved adolescents aged between 13 and 18 years. Since we were particularly interested in gender differences, only longitudinal studies reporting results separately for young women and young men were included in this review. We considered publications where social stressors were a result of major life events regardless of severity and duration. Criteria for exclusion included: cross-sectional design, exposure of interest lacking, overall stress levels (eg, cortisol, self-rated) as exposure, qualitative study, clinical populations, unspecified age group, lack of analyses by separate sex, non-metabolic outcome(s) (eg, psychopathology of body weight such as anorexia nervosa), weight management interventions, position papers, editorials and measurement validation studies.

Screening

Two reviewers (SXRG and ACTT) screened titles and abstracts for potential eligibility and removed records based on exclusion criteria. Abstracts were examined further for full-text retrieval, excluding additional records. Retrieved papers were read in full and references followed up.

Quality assessment, data extraction and analysis

SXRG and ACTT independently assessed quality using an adapted checklist of itemised criteria, consisting of 25 questions and 3 response categories ('yes', 'no' and 'cannot tell'). Criteria covered: research question, design, representativeness, sampling, protection against bias and confounding (ie, comparability), completeness, results, conclusions and generalisability. We added all the 'yes' responses across the 25 questions to assign an overall assessment of: 'high quality' when at least 80% of the criteria were met based on 'yes' responses; 'medium quality' when more than 20% but less than 80% of criteria were met and 'low quality' when 20% or fewer of the criteria were met, as previously reported.[27] Completed assessments were cross-checked between reviewers and the principal investigator (AIC). Studies were analysed using a standardised evidence table with a priori determined headings. SXRG and ACTT extracted data on: stated study objective, design, year, population, geographical setting, exposure description, outcome(s) measured, covariables, reported findings, author and source. Reported findings were synthesised through a narrative approach while quality assessment helped interpret and explain reported results. Any disagreements on eligibility, quality or synthesis were discussed with the principal investigator (AIC) and resolved by consensus.

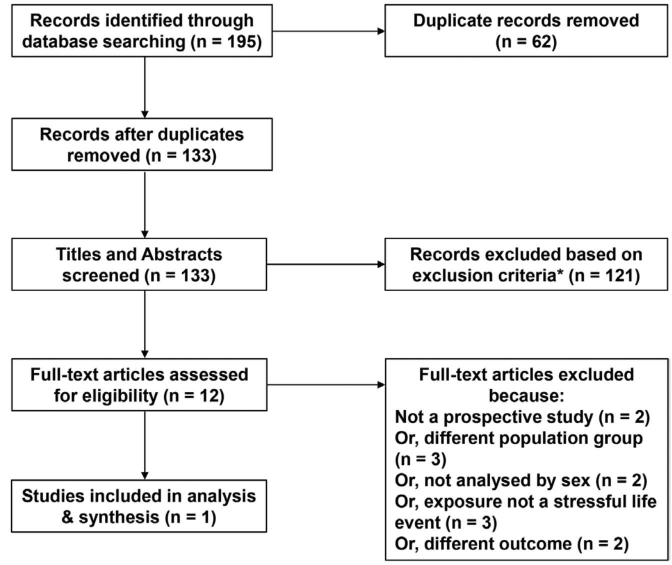

Figure 1 Modified PRISMA flow diagram of literature search and study selection. *Exclusion criteria: cross-sectional design, exposure of interest lacking, physiological stress, qualitative study, clinical populations, unspecified age group, lack of analyses by separate sex, non-metabolic outcome(s), weight management interventions, position papers, editorials and measurement validation studies. PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

RESULTS

Our search resulted in 116 original studies and 17 reviews (total n=133), after duplicates were removed (n=62). After screening titles and abstracts, we retrieved and screened 12 eligible full texts and found only one original paper meeting our review criteria for data extraction, quality appraisal and narrative synthesis (figure 1). Two eligible abstracts could not be read in full as the associated manuscript was not yet submitted for publication (Harkins, personal communications) or the authors did not respond to our full-text request. The included study reported on stressful life events and follow-up body mass index (BMI) from prospective cohort data collected between 1980 and 1986 in 671 young people from Finland,[28] and was identified by handsearching results found through Web of Science. Given the paucity of results, we provide reasons for the excluded studies at the end of this section.

Study quality

Despite being an older paper, our included study[28] was rated as medium quality as it satisfied approximately 70% of the quality criteria (online supplementary table S1). Criteria not met by this medium quality study concerned study completeness, poor reporting of results in available exhibits, limited control for bias and non-generalisability of findings. A major concern for quality is the lack of statistical adjustment for potential confounders such as socioeconomic status, depression or pubertal stage in the analyses. Moreover, this study used a random sample drawn from a larger population-based epidemiological cohort who represented specific age cohorts and lived in five university city areas across Finland, but the resulting subpopulation was representative of the original sample only with respect to age and gender.[28]

Study design and sample characteristics

This study used a before-and-after design with prospective cohort data (table 2). Participants were followed up every 3 years after baseline for a total of 6 years of observation. The sample size was 671, with participants randomly drawn from three age cohorts (13, 15 and 18 at baseline) within a larger epidemiological study. Analyses were stratified to examine gender differences in the impact of specific life events on change in metabolic syndrome parameters, with locus of control (LOC) as a moderator of interest.

Exposure definition

Ravaja *et al*[28] assessed exposure to stressful life events using a questionnaire asking participants to retrospectively report on 20 specified life events they had experienced in the previous 3 years, with a focus on ordinary life changes.[28] The authors used principal component analysis of highest factor loadings to group the 20 life event items into four factors: change in working/educational activities, personal illness, setting up a family and change in residence. Both the main effect of life events and the interaction of life events with LOC were studied, with subscale scores for each of the four life event factors used in analyses.

Outcome(s) examined

Our included study analysed change in metabolic syndrome parameters which included BMI as well as serum insulin, serum high-density lipoprotein cholesterol, serum triglycerides, systolic blood pressure. BMI (kg/m^2) was calculated from measured height and weight. All somatic parameters were assessed at the first and follow-up examinations.

Main findings

Findings reported by Ravaja *et al*[28] were mixed as different life changes had either positive or negative influence on metabolic function, however, most life events predicted an increased metabolic risk among the young cohorts studied.[28] The authors also examined whether associations were modified by LOC, and found they depended on the particular given life event analysed. Of particular interest to this review, the authors revealed notable gender differences in the relationship between normal life events and subsequent metabolic outcomes. More specifically, results showed that residence change was associated with significantly lower BMI in young men, whereas setting up a family was linked to higher BMI in young women.

Table 2 Characteristics of included studies

Source	Author	Stated study objective	Study design	Year(s)	Setting	Study population (n)	Description of exposure	Outcome(s) assessed	Reported findings
Hand searched	Ravaja *et al*[28]	(1) To examine whether life changes predict changes in the parameters of the metabolic syndrome in healthy young adults and (2) To determine if locus of control is a moderator of the relation between life changes and metabolic function	Longitudinal prospective cohort	1980–1986	Finland (random sample of five university city areas)	Healthy adolescents (n=671) (12, 15, 18 age cohorts)	20 specific life events, four groups (change in work or education activities; personal illness; setting up family; change of residence) Locus of control modifier (23-item Nowicki-Strickland, score 31–88)	Metabolic syndrome parameters, including measured body mass index (BMI)	Males: residence change significantly associated with lower BMI (beta −0.06, p=0.024) Females: setting up family significantly associated with higher BMI (beta 0.13, p<0.001), and modified by locus of control

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Characteristics of excluded studies

Our excluded studies[10 29–38] included a mix of cross-sectional and prospective longitudinal designs and typically involved populations of children to late adolescents, although several focused on adults (online supplementary table S2). Most of the excluded studies assessed general stress response levels that were either self-reported (ie, perceived) or clinically measured (ie, biomarkers), however, one Canadian study of girls,[33] one Dutch study[34] and one review of adults[38] specifically examined exposure to adverse life events as a social stressor. Studies predominantly measured BMI as the most common adiposity outcome.[10 27 29 30 32 33 36] Other outcomes included diet[30] and menses onset,[33] or were not sufficiently specified.[36 37] Moreover, excluded studies typically lacked an explicit gender perspective or did not report gender-specific associations,[10 29 31 34–37] or focused only on women.[32 33] In general, perceived overall stress appears to promote weight gain in young adults with a modest effect size. However, findings from the excluded studies were mixed and revealed complex relationships and lagged effects when studied from a life-course perspective.[29 34] Most of the excluded studies reported a positive association between stress, as a response or a social variable, and subsequent adiposity[10 31 34–38] but, several reported no relationship,[29 32 33 38] while others documented inverse associations.[34 38]

DISCUSSION

Synopsis

Although ample evidence exists on the relationship between stress response or sleep problems and obesity, this review found limited prospective evidence concerning how stressful life events as a social stressor influence obesity risk in young women and young men. Moreover, there were no relevant studies or reviews examining both stressful life events and sleep problems in relation to adiposity in adolescents. We identified a single longitudinal study of medium quality that was published over 20 years ago and showed a significant relationship between specific stressful life events and subsequent BMI. However, the direction of association differed between young women and young men depending on the type of life event: residence change was associated with decreased BMI in young men, while setting up family was associated with increased BMI in young women. The nature of a given life event, such as its age appropriateness, may determine whether it increases or decreases risk of obesity in young people.

Relevance to previous work

Several studies of children and young people demonstrate that both acute and chronic stress responses are linked to subsequent obesity.[10 29 31 35–37] Higher perceived stress was associated with adiposity in British adolescents,[35] and chronic stress increases the risk of childhood obesity in a dose–response relationship.[36] However, different levels of perceived stress do not appear to significantly alter the growth rate in BMI,[29] and the effects of reported stress on children's adiposity depends on cortisol levels and lifestyle factors.[31] Notably, greater perceived stress is likely to influence adolescent food choices which also have consequences for weight, as shown in a cross-sectional study of five European countries where diet quality decreased for both young women and young men as perceived stress increased.[30] Given the unique vulnerability of adolescents to effects of intense acute or chronic stress responses, it is perhaps unsurprising that a recent review concluded that chronically stressed adolescents develop elevated cortisol and insulin levels and these alterations affect body composition, leading to early-onset obesity particularly central obesity.[10] Moreover, the risk of obesity may be greater for chronically stressed young people with disturbed sleep due to the combined effects of stress pathophysiology with misalignment of circadian behaviours.[10]

Different stressors will activate distinct central neuroendocrine pathways and circuits implicated in the pathogenesis of stress-related disorders.[39] Notably, social stressors involving uncontrollability and social-evaluative threat, such as the Trier Social Stress Test, result in greater HPA activation and lower mood ratings than other common stressors used in experimental settings to induce acute stress responses.[40] Other environmental stressors also influence physiological and perceived physiological stress reactivity, including socioeconomic status, urbanicity, family situation, parenting behaviours and adverse life events.[41] Limited work suggests adverse life events are related to cortisol and heart rate reactivity in a gender-specific and age-specific manner.[41]

Our finding that specific stressful life events are differentially associated with subsequent adiposity is similar to results from a longitudinal study of Dutch children for whom adverse events and recent victimhood were related to lower BMI but adverse health events were linked to increased BMI in late adolescence.[34] However, gender-specific associations between adverse events and BMI were not reported in that study. In populations of middle-age to older-age adults, there is good evidence overall that stressful life events promote weight gain, with stronger effects reported in men than women.[38] Notably, women and men differ in the types of stressful life events experienced and sensitivity to their pathogenic effect,[42 43] which may explain the gender-specific impact of stressful life events on obesity risk. Hence, it is important to examine specific stressful life events and not only perceived or biological stress in order to better understand what life stresses influence weight in adolescents, how and for whom—information that is critical to designing appropriate and relevant interventions.

Strengths and limitations

This review may have missed other evidence from grey literature on stressful life events, alone or combined with sleep patterns, as determinants of weight status in young women and men, since this review predominantly focused on longitudinal studies in peer-reviewed publications. The criterion for age range might have been strict as it removed several relevant results for other populations. However, restricting to young adults aged 13–18 years was necessary in order to look at the adolescent population biologically marked by puberty. Our additional criteria on longitudinal studies, gender-specific estimates and sleep as a moderator may have further limited our results. Moreover, the multidisciplinary nature of our review topic could have contributed to the small number of identified studies given that much of the research in this area is conducted by the separate disciplines of biomedical sciences or psychology that typically focus on the stress response rather than stressors per se.

Nevertheless, this review is the most comprehensive to date, with searches conducted by two reviewers in six databases covering interdisciplinary literature from a wide range of social sciences, not only the medical field. There were no restrictions on publication date to allow for potentially older studies, and we used broad terms to help ensure the widest possible evidence was captured.

Implications for further research

Our finding of scarce robust evidence of stressful life events as determinants of adolescents' obesity risk is not new,[37 38] but one would expect the growth in empirical work on stress and obesity to advance the evidence base for improved public health policy and programming. There still exists a large knowledge gap concerning the role of stressful life events and obesity in adolescent age groups, and the elucidation of moderating variables. In addition, the inter-relation of stressful life events and sleep problems deserves more attention given the growing evidence linking sleep problems with metabolic health as well as the unique vulnerability of young people to increasing sleep problems. It is not insignificant that the majority of young people sleep less than the recommended number of 8–10 hours a night,[44] and that the quality of sleep is poor.[45] There is great scope to further investigate which stressful life events combine with what aspects of sleep (eg, quality, quantity, temporal occurrence) to influence obesity risk in either young women or young men. Moreover, since existing studies of either sleep or stress typically focus on BMI as the primary outcome measure, future research on stressful life events alone or combined with sleep problems, should examine other adiposity outcomes, such as waist circumference as a measure of central obesity. Important methodological considerations concern the absence of comparison groups in existing longitudinal studies which also rarely specify the duration or cumulative nature of the stressful life events examined. Thus, there is a need to improve on study design and assessment in future studies.

What has emerged from current research is a disparate body of evidence from different disciplines that tend to focus on the factor of interest to that discipline, with limited exploration of the intersection between these two well-acknowledged determinants of weight in young people which may have differential impact by gender. We, therefore, call on the public health research community to analyse and theoretically account for distinct stressful life events and their combined effects with sleep problems in relation to different anthropometric outcomes for young women and young men separately.

CONCLUSION

Although both stress and sleep are recognised determinants of weight, we still know little about stressful life events and obesity risk in young women and young men. Existing evidence is suggestive of differential impact of specific life events on weight in young women and men. There are no studies linking stressful life events to obesity with sleep as an effect modifier in adolescents, and begs the question whether sleep problems alter the association of stressful life events with obesity and for which gender. Robust, high-quality longitudinal studies to decipher this dual burden on obesity during adolescence should be prioritised in research as firm conclusions remain elusive.

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Contributors AIC and CGR conceived the study. ACTT and SXRG conducted the search, and extracted the data and quality assessed the included studies. AIC designed the study, informed study execution, interpreted data and led drafting. CGR, AIC, SXRG and ACTT revised the drafted paper critically for important intellectual content and all authors gave final approval of the version to be published.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient consent Not required.

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement No additional data are available.

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