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SUPPLEMENT ARTICLE

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Longitudinal relationship between adolescents' mental health, energy balance-related behavior, and anthropometric changes

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Summary

Energy balance-related behaviors (EBRBs) are considered the immediate causes of adolescents' body weight increases, but adolescents have identified mental health as a contributor. Cross-sectional studies have reported associations between adolescents' mental health and obesity, but causal relationships and the role of EBRBs within this can only be established using longitudinal studies. This systematic review summarizes the findings of longitudinal studies investigating this relationship, in addition to the role of EBRB in the relationship. Multiple electronic databases were searched for longitudinal studies using keywords related to the adolescent population, mental health, EBRB, and body weight. In total, 1216 references were identified and screened based on previously defined eligibility criteria. Sixteen articles met the inclusion criteria. Most studies indicated that mental health-related measures like depression, anxiety, and body dissatisfaction were related to an increase in body weight later. As this review is focused on behavioral mediators, six studies reported associations between mental health—anthropometry dyad and EBRBs such as eating habits, screen time, physical activity, and sleep—as well as stressors like peer victimization. Future studies may focus on streamlining mental health measures and body weight outcomes to assess this relationship. Furthermore, more longitudinal investigations are needed to provide insight into the role of EBRBs in the mental health–body weight relationship during adolescence.

KEYWORDS
adolescents, body weight, energy balance-related behavior (EBRB), longitudinal, mental health

1 | INTRODUCTION

Adolescence is a critical period in human growth and development.[1,2] The transition from childhood to adulthood is associated with significant and often chaotic physiological and psychosocial experiences.[2,3] Furthermore, the poor state of adolescents' physical health may have severe long-term implications on their development into adulthood.[4,5] One of the most common challenges to the physical health of

adolescents is overweight and obesity. By 2016, an estimated 18% of girls and 19% of boys were overweight, while 6% of girls and 8% of boys were obese globally.[6]

Weight gain is considered as the product of multiple (e.g., social, environmental, and physical) factors resulting in a positive energy balance (i.e., energy intake exceeding energy output). Multiple behaviors contribute to the energy balance[7,8] and are referred to as energy balance-related behaviors (EBRBs). EBRBs leading to excess energy include high consumption of ultra-processed and fat-based foods, diets low in fiber, fruit, and vegetables, high intake of sucrose (for example, sugar-sweetened beverages), insufficient daily physical activity to increase energy output,[8] as well as short duration and low-quality sleep in younger age groups.[9,10] Studies agree on the significant role that EBRBs play in weight gain, but a more complex interplay of intrapersonal determinants, including psychological and emotional factors, may be driving adolescent obesity.[11–13]

Recent studies seeking to understand factors contributing to adolescents' overweight reported that adolescents in Europe and South Africa identified poor mental health as a potential contributor to youths' overweight and obesity.[14,15] According to the World Health Organization (WHO)'s constitution, "Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity." Hence, mental health is an integral part of the general perception of health and wellbeing.

Mental health is a complex concept, but generally refers to assessing emotional and psychological well-being in relation to concepts like subjective well-being, perceived self-efficacy, autonomy, competence, intergenerational dependence, and self-actualization of one's intellectual and emotional potential, among others.[16] It is also linked to mental wellbeing, quality of life assessed by the individual's knowledge of his or her own abilities, ability to cope with life stressors and distressful situations among other variables.[17] Mental health conditions refer to a broad range of issues with symptoms characterized by combinations of abnormal thoughts, emotions, behavior and relationships with others.[17]

In adolescents, mental health status is influenced by key determinants related to personal attributes like managing one's own thoughts, emotions, behaviors, and interactions because of environmental stressors like academic performance, perceived body image, familial and romantic relationships, and family socioeconomic status.[18,19] Emotional and psychological well-being could be compromised, and adolescents' mental health is significantly affected by these determinants because of the rapid changes and transitions that occur during adolescence. Globally, nearly 50% of adolescents may experience some mental health-related conditions at some point in their lives.[20] However, the impact of mental health on adolescents' body weight changes is unclear.

Numerous cross-sectional studies and reviews, including those by Adoms et al.,[21] Avila et al.,[22] and Burke et al.,[23] have investigated the relationship between adolescents' mental health and body weight and the mediating role of EBRBs, as well as other socio-demographic (for example, age and sex) and -cultural (for example, gender roles and body perception) factors in this association. These cross-sectional studies showed an association between stress and increased body weight through changes in lifestyle choices, specifically decreased physical activity and increased unhealthy diet.[13] Some cross-sectional studies reported associations between depression or anxiety and body dissatisfaction, disordered eating behaviors, lifestyle choices, and body weight among adolescents.[24,25] There is also a link between mental health and body mass index (BMI).[26]

Previous systematic reviews on the longitudinal relationship between mental health and anthropometry variables were focused on a specific mental health condition. For example, Mannan et al.[11] reported a bi-directional longitudinal association between depression and obesity during adolescence, while Conklin et al.[27] investigated the combined effect of sleep and stressful life events on adolescent obesity. There is an existing gap in knowledge on the summary of the long-term association of a broad range of adolescents' mental health states and conditions, including positive and negative measures of anthropometric changes.[23,28,29] It is also important to understand if EBRBs alone play a significant mediating role in this relationship longitudinally. To our knowledge, there is no report that has reviewed, summarized, and analyzed existing findings to provide directions for further investigations on broad-based, multi-scale adolescent-related mental health and body weight changes and their behavioral mechanisms.

Hence, the aim of this systematic review is to summarize key findings from longitudinal studies that investigated changes in body anthropometry associated with mental health-related factors and further investigate the mediating role of EBRB in these relationships within adolescents. The specific questions explored in this review for adolescents are:

a. Is there a long-term/longitudinal relationship between mental health and EBRBs, and what is the direction of this relationship?
b. Is there a long-term relationship between mental health and anthropometry, and what is the direction of this relationship?
c. Do EBRBs mediate the relationship between mental health and anthropometry?

2 | METHODS

2.1 | Study design and eligibility criteria

The study design for the systematic review was outlined in a protocol that followed the preferred reporting items for systematic review and meta-analysis (PRISMA) guidelines.[30,31] The protocol is registered and published on PROSPERO with the registration number CRD42021290229.

In this review, the **Population** of interest is adolescent (10–19 years) cohorts assessed for **Exposure** to stressors or their mental health status or psychological wellbeing. **Outcomes** of interest are changes in adolescents' anthropometrics and EBRBs, with a focus on longitudinal, quantitative **Studies** using the PEOS approach.[31]

All studies included in the review met the following criteria: They were primary empirical and quantitative research published no later than December 2022. There was no limit to the earliest date for study inclusion because an initial search showed that no prior systematic review has been conducted on this long-term relationship and few

primary studies have focused on investigating the longitudinal relationship. In addition, included studies had to report on changes in adolescents' body weight or EBRB related to mental health status with a longitudinal focus. The age range of study participants (10–19 years) in the included studies was defined according to WHO's standard[32] and was applied across all timepoints for all reviewed studies. No language filter was applied to the inclusion criteria during the online database search, and all abstracts were written in English. Database filters were applied to limit eligible studies to only those that used humans as study participants.

2.2 | Data sources, search strategy, and selection of relevant study

A comprehensive search was conducted in the following databases: MEDLINE (PubMed), Cochrane Central Register of Controlled Trials (CENTRAL), EMBASE (Scopus), EBSCOhost (including Africa-Wide Information, Cumulative Index to Nursing and Allied Health Literature [CINAHL], Health Source: Nursing/Academic Edition, APA PsycArticles, APA PsycInfo), and Web of Science based on the above eligibility criteria.

Terms used in searches were derived from subject headings and keywords from an initial search that was related to the adolescent population and mental health. The main search terms included mental health (including Mental Health, Stress, Psychological Stress, Life Stress, Psychologic Stress, Stressor, Psychological Stressor, Psychological Stress, psychosocial stress, distress, psychological wellbeing, mental wellbeing, emotional wellbeing, quality of life, happiness, and health related quality of life), EBRB, anthropometry, and longitudinal study types. A detailed search strategy adapted for PubMed is included in Supplementary Table 1. Searches on other databases used similar subject headings and keyword terms, with only changes made to suit each database's search syntax. Furthermore, the reference lists of eligible studies were manually checked to identify other relevant studies. All references from the databases were exported first to Endnote X9 (https://endnote.com/), and thereafter identified duplicates were removed. Studies have noted the complexity of de-duplication and the limitation of using only Endnote for this purpose, particularly based on the titles of references. Therefore, it is recommended to include either Rayyan, Covidence, or Ovid in the deduplication process.[33,34] Hence, for quality assurance purposes, the remaining references after de-duplication were imported into Rayyan (https://rayyan.qcri.org/), screened further, and other identified duplicates were removed.[35] Titles and abstracts from articles of the remaining references were screened by two independent reviewers for eligibility using Rayyan.[35] Disagreements about eligibility were resolved by a third reviewer. Full-text copies of articles that met inclusion criteria from the title and abstract screening were obtained and assessed by two independent reviewers for inclusion in the review. Disagreements about eligibility during full-text screening were resolved with a third reviewer through discussions.

2.3 | Data extraction

Extraction was performed using a datasheet designed for the study through discussion by all reviewers and piloted on three randomly selected eligible articles by three independent reviewers. The following information was extracted for each article; study details—article's year of publication, authors names, the study aims and objectives, study type (exploratory, observational, and intervention), number of longitudinal waves or time points, study setting and location, sample or population size, groupings within study participants, age range of study participants (mean and standard deviation), duration of longitudinal study, if study received ethical approval and the organization that gave approval, if article was appraised for the systematic review, mental health measures, body anthropometric and EBRB outcomes, relevant findings showing the relationship between outcomes and measures of interest, whether mediation analyses were done and conclusion.

2.4 | Quality assessment

The "Effective Public Health Practice Project (EPHPP) quality assessment tool for quantitative studies"[36] was used to assess the quality of the methodology for the included studies based on six criteria, namely, selection bias, study design, confounders, data collection methods, withdrawals, and drop-outs. Details of the quality assessment tool questions are provided in Supplementary table 2. Each study was rated by two independent reviewers as weak, moderate, or strong for each of the six criteria, and the overall methodology rating of the study was summarized as weak (for two or more weak ratings in the six criteria), moderate (for one weak rating), and strong (if there is no weak rating). Any disagreement in rating was resolved through discussion with a third reviewer. The final rating for each of the included studies is reported in Table 1.

2.5 | Data synthesis

A narrative summary approach, instead of a meta-analysis, was applied in this systematic review because of the need to understand the long-term impact, not the size of the effect, of adolescents' mental health on body anthropometry as well as the implication of adolescents' behavior on this relationship. Furthermore, the diversity in assessment tools used in measuring the three variables of interest (about 24) and wide variations in aspects[35] of mental health, EBRB, and anthropometric outcomes measured make pooling data from different studies for statistical analysis difficult; hence, conducting a meta-analysis will not be ideal. Each study was summarized based on findings on similar variables as outlined in the data extraction section. Furthermore, we summarized the reported relationships between measures and outcomes from the results of the studies. Conclusions about findings from each study were summarized and reported in this review. Study sample size, number of time points, study locations, and

TABLE 1 Summary of characteristics of the included studies for adolescents' broad mental health relationship with body anthropometric changes and energy balance-related behaviors (EBRBs).

	First author(year)	Country	• Study duration (D)
			• Number of time points (Ntp)
			• Frequency of data collection (Df)
				• Sample size (*N*)
				• No. of boys/girls
					Age
					*Mean (SD) years
					#Age range
					yrs = Years
						Relevant measures and outcomes
						Body weight outcome
							Mental health measures	EBRB outcome	EPHPP rating

1.	Aparicio (2013)	Spain	• D = About 4 yrs • Ntp = 3 • Df = 1 and 3 yrs after baseline	*N* = 229 Boys: 87 Girls:142	T1: 10.2 (1.2)* yrs T2: 11.2 (1.0)* yrs T3: 13.5 (0.9)* yrs	• BMI (measured weight, height) • Measured waist circumference • Body composition (Bioelectrical impedance BIA) - fat mass (kg) - body fat percentage (%BF)	• Anxiety symptoms, anxiety disorders (panic disorder with or without agoraphobia), Separation anxiety disorder, Generalized anxiety (disorder & social phobia) - Screen for Childhood Anxiety and Related Emotional Disorders (SCARED)[37] • Depressive symptoms, depressive disorder and dysthymia (Children's Depression Inventory [CDI])[38] • Body satisfaction (Body Areas Satisfaction Scale [BASS])[39]	• Dietary quality (Dietary quality was measured with Krece plus food questionnaire).[40] • Physical activity (Krece Plus physical activity questionnaire: the Krece Plus short physical activity test).[41]	Moderate
2.	Chang (2017)	Taiwan	• D = 4 yrs • Ntp = 4 • Df = Annually	*N* = 1893 Boys: 924 Girls: 969	T1: 14.7 (0.5)* yrs Age at other time points not provided.	• Self-reported Weight and height • calculated BMI (kg/m2), • BMI z-score	• Peer victimization measure (adapted from social experiences questionnaire).[42] • Depressive symptoms measure (adapted from the Center for Epidemiological Studies Depression Scale for Children).[43]	• Sleep problem measure (Pittsburgh Sleep Quality Index in 2009 and 2011[44]	Moderate
3.	Clark (2007)	United Kingdom	• D = 2 yrs • Ntp = 2 • Df = 2 yrs after baseline	*N* = 1615 Boys: 800 Girls: 815	T1:11–12 & 13–14 yrs# T2:13–14 & 15–16 yrs#	• Measured weight, and height. • Calculated BMI	• Psychological distress (Strengths and Difficulties Questionnaire [SDQ]). • Depressive symptoms (Short Moods and Feelings Questionnaire [SMFQ])	• Physical activity defined as "active" or "inactive", i.e. exercising more or less than twice a week for one hour	Strong

TABLE 1 (Continued)

	First author(year)	Country	• Study duration (D)
			• Number of time points (Ntp)
			• Frequency of data collection (Df)
				• Sample size (*N*)
				• No. of boys/girls
					Age
					*Mean (SD) years
					#Age range
					yrs = Years
						Relevant measures and outcomes
						Body weight outcome
							Mental health measures	EBRB outcome	EPHPP rating

4.	Côté-Lussier (2015)	Canada	• D = 12 yrs • Ntp = 3 • Df = Annually	*N* = 1,234 Boys: 568 Girls: 666	T1: 13.1 (0.3)* yrs Age at other time points not provided.	• Measured weight, height • Calculated BMI	• Feelings of safety at school using 5-point Likert scale • Victimization	• Self-reported screen time as hours per week • Self-reported days per week (0–7 days) of engaging in physical activity at home, school, or elsewhere	Moderate
5.	Faulkner (2020)	Canada	• D = 2 yrs • Ntp = 2 • Df = Annually	*N* = 2292 Boys: 1063 Girls: 1229	T1: 15.3 (0.5)* yrs T2: 16.3 (0.5)* yrs T3: 17.3 (0.5)* yrs	• Self-reported Weight and height • BMI classification based on WHO z-scores[45] adjusted for sex and age	• Psychosocial prosperity level and well-being (Diener's Flourishing Scale [FS])[46] • Depressive symptoms at Year 5 of the study (Center for Epidemiologic Studies Depression Scale-(Revised)-10 (CESD-R-10)).[47]	• Complying with the Canadian guidelines for: • Physical activity (PA) - of at least 60 min/day over the last 7 days • Screen time (ST): <2 hrs of recreational ST/day • Sleep of between 8–10 hours of sleep/day	Moderate
6.	Felton (2010)	United States of America	• D = 4 months • Ntp = 2 • Df = 4 months after baseline	*N* = 215 Boys: 107 Girls: 108	T1: 11.8 (0.8)* yrs. 11–19 years old#.	• Weight and height (measured and self-reported). • BMI (measured weight and height). • Body fat • Futrex 6,100 (Near infrared (NIR) method) • Tanita scale BF-522 (BEI technique) • Body shape and image • Silhouette Assessment of Body Shape (SABS). • Multidimensional Body–Self Relations Questionnaire (MBSQR) • physical appearance subscale of the Self-Perception Profile for Adolescents (SPPA).	• Number and severity of depressive symptoms assessed with The Children's Depression Inventory (CDI) questionnaire. • Recent depressive symptoms assessed with The Center for Epidemiological Studies-Depression scale for Children (CES-DC) questionnaire.	• Eating attitudes were examined by The Eating Attitudes Test (EAT-26)	Moderate

(Continues)

TABLE 1 (Continued)

	First author(year)	Country	• Study duration (D)
			• Number of time points (Ntp)
			• Frequency of data collection (Df)
				• Sample size (*N*)
				• No. of boys/girls
					Age
					*Mean (SD) years
					#Age range
					yrs = Years
						Relevant measures and outcomes
						Body weight outcome
							Mental health measures	EBRB outcome	EPHPP rating

7	Hoare (2016)	Australia	• D = 2 yrs • Ntp = 2 • Df = 2 yrs after baseline	*N* = 634 Boys: 296 Girls: 338	T1: 13.1 (0.6)* yrs T2: 15.1 (0.6)* yrs	• Measured weight status - Overweight/obese (WHO)	• Depressive symptoms using the Short Mood and Feelings Questionnaire (SMFQ).[48]	• Sedentary behavior >2 h/day, • Physical activity - Inactive/low active, • Diet - Failed to meet fruit and vegetable recommendations, • Takeaway consumption at least once a week. • Sweet drink consumption -Daily mean (SD) of glasses of sweet drinks consumed (including soft drinks, energy drinks, cordial and fruit drinks)	Strong
8	Hootman (2018)	United States of America	• D = 1 yr • Ntp = 2 • Df = 1 yr after baseline	*N* = 241 Boys: 116 Girls: 125	T1 = 18.1 (0.3) Yrs Age at other time point not provided.	• Measured weight and height. • Measured waist circumference (WC). • Measured hip circumference. • Measured total body fat percentage and fat mass index (whole body scan with dual energy X-ray absorptiometry).	• Positive attitude and flexible approach towards food (Satter Eating Competence Inventory (ecSI) questionnaire. • Stressfulness of life situations (Perceived Stress Scale [PSS]). • Eating behavior (restraint, disinhibited eating and emotional eating - Three Factor Eating Questionnaire (TFEQ).	• Physical activity (Global Physical Activity Questionnaire (GPAQ). • Usual diet over previous year (Food frequency questionnaire the Diet History Questionnaire (DHQII) • Number of daily meals and snacks	Strong
9	Kipp (2021)	United States of America	• D = 16 Weeks • Ntp = 2 • Df = 16 Weeks after baseline	*N* = 148 Parents–child dyads Boys: 53 Girls: 95	T1 = 12.9 (1.8)* yrs 11–16 yrs#	• Measured height and weight. • BMI • Adolescent BMI z-scores (CDC growth reference curve)	• Perceived stress (10-item version of the Perceived Stress Scale [PSS])[49]		Weak

TABLE 1 (Continued)

	First author(year)	Country	• Study duration (D)
			• Number of time points (Ntp)
			• Frequency of data collection (Df)
				• Sample size (*N*)
				• No. of boys/girls
					Age
					*Mean (SD) years
					#Age range
					yrs = Years
						Relevant measures and outcomes
						Body weight outcome
							Mental health measures	EBRB outcome	EPHPP rating

10	Lloyd (2020)	United Kingdom	• D = 4 yrs • Ntp = 3 • Df = Annually	N = 2406 girls Boys: None Girls: 2406	T1: 13–14 yrs# T2: 15–16 yrs# T3: 17–18 yrs#	• Measured weight and height. • BMI classification (WHO and International Obesity Taskforce standard)	• Anxiety disorders: presence of generalized anxiety disorder, social phobia, specific phobia, panic disorder, separation anxiety disorder and agoraphobia previously in lifetime, measured with Development and Wellbeing Assessment (DAWBA).[50]	• Fasting for weight loss behavior - Whether participants engaged in • fasting behavior on at least a monthly basis during the previous year,	Moderate
11	Micali (2014)	United Kingdom	• D = 2 yrs • Ntp = 2 • Df = Annually	*N* = 7071 Boys: 3528 Girls: 3543	T1: 13.1 (Girls = 0.17; Boys = 0.18)* yrs Age at other time point not provided.	• Measured weight and height at 13 and 15 years old. • Calculated age- and gender-adjusted BMI z-scores.	• Parent-reported presence of any DSM-IV or ICD-10 emotional and behavioral disorder • Parent-reported fear about weight gain, behaving upset or distressed about weight and shape. • Parents completed Developmental and Well-being Assessment (DAWBA) for all other mental health disorders. • Variables indicating presence of any DSM-IV or ICD-10 emotional and behavioral disorder were obtained from the DAWBA using computer algorithms.		Moderate
12	Micali (2015)	United Kingdom	• D = 2 yrs • Ntp = 2 • Df = 2 yrs after baseline	*N* = 6158 Boys: 2742 Girls: 3416	T1 = 14.0 (0.19)* yrs. T2 = 16.7 (0.24)* yrs	• Measured weight and height. • BMI • Age- and gender-adjusted cut offs for	• Depressive symptoms (Moods and Feelings Questionnaire). • Anxiety disorders diagnoses (DAWBA		Moderate

(Continues)

TABLE 1 (Continued)

	First author(year)	Country	• Study duration (D)
			• Number of time points (Ntp)
			• Frequency of data collection (Df)
				• Sample size (*N*)
				• No. of boys/girls
					Age
					*Mean (SD) years
					#Age range
					yrs = Years
						Relevant measures and outcomes
						Body weight outcome
							Mental health measures	EBRB outcome	EPHPP rating

						adolescents (from the International Obesity Task Force).	anxiety disorders section) and Clinical Interview Schedule-Revised (CIS-R). • Deliberate self-harm (DSH): (from the DAWBA)		
13	Mougharbel (2020)	Canada	• D = 5 yrs • Ntp = 3 • Df = Not provided	*N* = 1197 Boys: 475 Girls: 722	T1 = 13.5 (1.1)* yrs Age at other time point not provided.	• Measured weight and height. • Calculated BMI. • Age and sex-specific percentiles and the matching BMI z-scores (WHO 2007)[51]	• Disordered eating (Dutch Eating Behavior Questionnaire [DEBQ]).	• Sedentary Screen Time (ST) (Leisure-Time Sedentary Activities six-item questionnaire)[52] • Total ST and individual ST behaviors (TV watching, computer use, video games)	Weak
14	Puterman (2016)	United States of America	• D = 10 yrs • Ntp = 10 • Df = Annually	*N* = 2379 Boys: None Girls: 2379	T1(mean) = 10.1 yrs Age at other time point not provided.	• Each year, weight and height were measured twice. • BMI (rather than BMI percentile)	• Perceived psychological stress (14-item Perceived Stress Scale (PSS)[53]	• Self-reported physical Activity Patterns through Questionnaire[50,52]	Weak
15	Rosenthal (2015)	United States of America	• D = 2 yrs • Ntp = 2 • Df = 2 yrs after baseline	*N* = 644 Boys: 283 Girls: 361	T1: 10.89 (0.73) yrs. Age at other time point not provided.	• Measured height and Weight. • Change in height. • BMI (kg/m2)	• Weight and Race based bully (Adapted from Haines et al.[53] and Neumark-Sztainer et al[54]) • Negative emotion measures (being unhappy, worried, depressed, or nervous)	• Physical fitness and eating habits adapted from Health Behavior in School-Aged Children: WHO Collaborative Cross-National Study	Moderate
16	Solmi (2018)	United Kingdom	• D = 5 yrs • Ntp = 2 • Df = 5 yrs after baseline	*N* = 6361 Boys: 3131 Girls: 3230	T1: 13 yrs T2: 18 yrs	• Measured height and Weight. • BMI	• Absence/presence of suspected or definite psychotic symptoms		Moderate

Abbreviations: T1, time point 1; T2, time point 2; T3, time point 3.

age range of participants provided the basis for determining the significance of findings. The most relevant findings and conclusions of the studies are reported in Table 2, and textual conclusions were drawn based on these.

3 | RESULTS

3.1 | Description of included studies

Figure 1 shows a PRISMA flow chart of references and the process of selection and inclusion of studies for the review. A total of 1216 references were identified through searches of databases, manual searches, and grey literature. After de-duplication, 951 references were screened for eligibility based on the title and abstract. Sixty-two[37] of the articles were eligible and selected for full-text review; of these, 16 met the inclusion criteria and were retained in this review. Table 1 shows the summary and characteristics of all studies that met the inclusion criteria.

All eligible studies reported findings based on non-clinical samples. Furthermore, none of the studies' participants were reported to be on mental health medication, which could influence body weight changes.[60] All studies' participants were assessed with either a questionnaire or self-reported mental health status.

3.2 | Study setting, design, and populations

Of the 16 studies, five were conducted in the United States of America (USA) and United Kingdom (UK), respectively; three were conducted in Canada; and one was conducted in each of Spain, Taiwan, and Australia. The included studies were published between 2007 and 2021, with a total sample size of 48,866 (range: 148–8886) participants. Participants in the studies were all adolescents within the age range of 10–19 years, except for one study,[61] which included adolescents' parents, but only adolescents' related findings were included in this review. All the studies had a longitudinal design: eight studies had two time points, six had three time points, and one study each had 10 and 12 time points, respectively; hence, studies' durations were between 4 months and 12 years.

3.3 | Methodological quality

Based on the EPHPP quality assessment tool, three studies were overall rated as "weak" or "strong," while 10 were rated as "moderate" (Table 1). The three studies rated as "weak"[61–63] were because of poor or unclear reporting on the study design or withdrawal and dropout criteria of the EPHPP assessment tool. Most studies rated as "moderate" did not clearly describe the selection bias as well as the withdrawals and dropouts encountered while conducting the study.

3.4 | Mental health measures

In the included studies, mental health measures reported include depressive disorders, symptoms and mood,[28,64–69] psychological distress or perceived stress level (scale) or psychosocial prosperity and wellbeing,[28,61,63,66,70] fear about weight gain and being upset or distressed about weight and shape,[71] anxiety disorder/symptoms,[64,69,72] body satisfaction or perceived body image,[64,67] peer victimization and bullying (weight- and race-based),[65,73,74] and psychological domains of disordered eating.[62,70] Other mental health measures reported include variables indicating the presence of mental disorders in the Diagnostic and Statistical Manual, fourth edition (DSM-IV) or tenth revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-10), related emotional and behavioral disorders,[71] self-harm, and negative emotion measures—being unhappy, worried, depressed, or nervous[69,74]—and the absence/presence of suspected or definite psychotic symptoms.[75] All mental health measures reported in the eligible studies were assessed using validated questionnaires or assessment tools.

3.5 | Body anthropometry outcomes

Most included studies reported measured or self-reported weight and height of participants, and the BMI values were calculated. Lloyd et al.[72] determined weight status using age, sex, UK reference data, and a WHO-defined cut-off, while Hoare et al.[68] used WHO 2007 reference age-specific BMI cut-offs to classify the BMI z-score. In addition, BMI z-scores were reported by four studies,[61,62,65,71] and waist circumference was reported by two studies.[64,70] Measured hip circumference, total body fat percentage, and fat mass index were reported by Hootman et al.[70] Body fat measures (using bioelectrical impedance (BEI) and near infrared (NIR) techniques) and shape (using Silhouette Assessment of Body Shape [SABS] for children and adolescents[76]) were reported by Felton et al.[67]

3.6 | EBRB—related outcomes

Eligible studies reported EBRB outcomes and interventions, including dietary quality,[64] daily fruit and vegetable intake,[68] takeaway and sweet drink consumption,[68] dietary intake assessing total energy and macronutrient consumption, number of daily meals and snacks,[70] aerobic fitness, physical activity patterns or fitness, exercising for weight loss, or excessive exercise,[28,63,64,66,68–71,74,75,77] as well as sleep problems or complying with recommended sleep guidelines,[65,66] self-reported or measured sedentary screen time,[62,66,73] and other sedentary behaviors.[68] Table 2 summarizes the main findings and conclusions of the included longitudinal studies.

TABLE 2 Summary of study findings for adolescents' broad mental health relationship with body anthropometric changes and energy balance-related behaviors (EBRBs).

s/n	First author [publication year]	Main findings	Study conducted EBRB mediation assessment	Conclusion
1.	Aparicio et al. [2013]	• Anxiety and depression around age 10 years have a positive association with increased weight, adiposity, and waist circumference in adolescence (around age 13 years). • Depressive and anxiety symptoms precede reduced levels of physical activity, which are associated with weight gain.	Mediation analysis was not conducted.	• Worsening mental health status earlier in adolescence is associated with greater amounts of fat gain, especially abdominal fat, in later adolescence, which could precede obesity or metabolic syndrome.
2.	Chang et al. [2017]	• The association between BMI (body weight) and depressive symptoms is significantly mediated by peer victimization (a stressor). • The association between BMI and depressive symptoms was mediated by sleep problems (EBRB). • Adolescents with a higher BMI experienced more peer victimization, which was associated with higher levels of depressive symptoms. A higher BMI was also associated with more sleep problems, which in turn contributed to higher levels of depressive symptoms. Higher BMI was associated with more peer victimization, which preceded greater sleep problems, which in turn resulted in increased depressive symptoms.	**Peer victimization** and **sleep problems** mediated the relationship between depressive symptoms and BMI, and the mediation did not differ by gender.	• The association between BMI and depressive symptoms was significantly mediated by peer victimization and sleep problems. Adolescents with a higher BMI had an increased risk of depressive symptoms due to higher levels of peer victimization and sleep problems. In addition, the mediating effects of peer victimization and sleep problems were similar across sexes.
3.	Clark et al. [2006]	• No association was found between levels of physical activity at baseline and mental health at follow-up. • Physical activity levels as an individual factor were not predictors of mental health—psychological distress or depressive symptomatology. • No findings of gender differences in the relationship between mental health.	Mediation analysis was not conducted.	• The lack of associations observed between physical health and mental health may be because of the short follow-up period. The pathways of risk between obesity, physical activity, and mental health may occur later in adolescence or take longer to develop than the 2-year time frame of the study.
4.	Côté-Lussier et al [2015]	• Association between weight status and feeling safe (a mental health-related stressor) persisted even after adjusting for victimization. • Youths experiencing chronic poverty (mental health-related stressors) were more likely to live with overweight/obesity than those who did not experience chronic poverty. However, there is no significant indirect association between weight status through physical activity levels and poverty level. • Less screen time was found in children who felt safer in schools.	Mediating variables reported are: • screen time (time/week spent watching on the screen over the past 3 months) • Physical activity (days per week spent on physical activities at home, school, or elsewhere)	• Experiencing mental health-related distress is associated with engaging in poorer weight-related behaviors and with unhealthy weight. • Feeling unsafe at school (a mental health measure) is a risk factor for obesity.

TABLE 2 (Continued)

s/n	First author [publication year]	Main findings	Study conducted EBRB mediation assessment	Conclusion
		• Marginally significant ($p < 0.05$) increased risk of pediatric overweight/obesity related to poverty and decreased feelings of safety. • Direct association between perception of safety and decreased risk of overweight/obesity		
5.	Faulkner et al [2020]	• Meeting moderate and vigorous physical activities (MVPA) and sleep guidelines at two timepoints was associated with greater flourishing (positive mental health measure). • Sleep quality and duration had stronger associations with flourishing and positive mental health compared with behaviors such as physical activities (PA). • Meeting recommended sleep guidelines is associated with lower adiposity indicators and better mental health indicators (emotional regulation and quality of life/well-being). • Findings support calls for the prioritization of sleep health by the public health community to come closer in line with the attention and resources given to other lifestyle behaviors such as PA and screen time (ST).	Mediation analysis was not conducted.	• There is evidence supporting the relationship between movement behaviors (MVPA, ST, and sleep), particularly sleep, and flourishing among youths. Promoting positive messages (gain-framed messages) may be more beneficial than negative messages (loss-framed messages); for example, with regards to sleep, loss-framed messages emphasize the costs of inadequate sleep (e.g., lack of sleep increases the risk of depression), whereas gain-framed messages emphasize the benefits (e.g., sufficient sleep will help you flourish).
6.	Felton et al. [2010]	• Among girls, there is a positive relationship between more depression at one time point and increase in body fat at other time points. • Depression scores were related to weight gain for older adolescents and weight loss for younger adolescents. • Depression was related to weight gain for girls and weight loss for boys. • The relation of depression scores to changes in body fat was significant ($p < 0.05$) for girls but not for boys. • The relation of depression scores to perceived change in size was significant ($p < 0.05$) for both girls and boys, but in opposite directions. • More depressed girls perceived themselves as having gained weight when they actually gained body fat. More depressed boys perceived themselves as having lost weight, a condition not supported by the BEI index of body fat (or any of the other physical measures).	Mediation analysis was not conducted.	• The relationship between physical measures of weight change and depressive symptoms varied with age. These relationships were explained by individual differences in body dissatisfaction, eating attitudes, and behaviors, leading to questions about weight change as a symptom of depression in adolescence.

(Continues)

TABLE 2 (Continued)

s/n	First author [publication year]	Main findings	Study conducted EBRB mediation assessment	Conclusion
		• Higher depression scores were associated with less healthy eating attitudes and behaviors and worse body image.		
7.	Hoare et al. [2016]	• Longitudinal analyses revealed males who were classified as overweight or obese at baseline and remained overweight/obese at follow-up reported significantly increased depressive symptomatology total scores compared with males who were normal weight at both time points. • Males who were classified as inactive at both time points also experienced significantly increased depressive symptomatology scores compared with active males. For females, those who reported monthly consumption of takeaway foods or less at baseline but increased to weekly or daily consumption at follow-up had increased odds of depressive symptomatology at follow-up.	Mediation analysis was not conducted.	• Adolescents experienced high levels of depression and obesity and exhibited poor dietary and physical activity behaviors. • The true relationships between these health issues are likely to be multiple and complex and most likely differ by population, including by gender. • The study supports addressing diet and physical activity as the foundation for the adolescent population's obesity and mental health outcomes.
8.	Hootman et al. [2018]	• Overall, no association was observed between baseline perceived stress and changes in anthropometry variables; however, sex differences were apparent. • In males, perceived stress at the study baseline was significantly and positively associated with changes in weight, BMI, and waist circumference. In females, perceived stress was inversely associated with a change in anthropometry, but the associations did not reach statistical significance thresholds. These findings suggest that stress may contribute to weight gain differently in males compared with females because of the differential effects of stress on dietary intake and/or internal hormonal regulators of energy utilization.	Mediation analysis was not conducted.	• Perceived stress was associated with subsequent changes in anthropometry in males only, such that greater stress at the start of college predicted greater increases in weight, BMI, and WC. The sex-specific association between stress and weight gain may be related to a greater stress response to academic and/or other challenges in males compared with females and/or to a sex-specific influence of stress on food intake, energy balance factors, and/or metabolism.
9.	Kipp et al. [2021]	• Parent-perceived stress did not independently predict adolescent z-BMI. • A significant ($p < 0.05$) interaction was found between parent-perceived stress and parental pressure to eat when predicting adolescent z-BMI. Parents whose adolescents reported high parental pressure to eat reported that parental perceived stress was positively associated with adolescent z-BMI.	Mediation analysis was not conducted.	• Certain parenting practices interact with chronic stress on adolescent weight-related outcomes, and future interventions may consider integrating these factors.

TABLE 2 (Continued)

s/n	First author [publication year]	Main findings	Study conducted EBRB mediation assessment	Conclusion
		• Parental pressure to eat, from the perspective of the adolescent, moderated parental perceived stress in predicting adolescent z-BMI at 16 weeks of follow-up. This finding means that parents who exhibited both higher pressure to eat and higher stress demonstrated a clinically meaningful increase in their child's BMI.		
10.	Lloyd et al. [2020]	• Anxiety disorder presence predicted an increased likelihood of engagement in behaviors like fasting at later time points, especially among girls. • Anxiety disorder prediction of the increased risk of fasting is stronger at later time points. • The collection of findings suggests that the predictive influence of anxiety on fasting varies over time: anxious pathology in childhood and mid-adolescence predicts an increased risk of later fasting, while anxious pathology in early adolescence does not. • While anxiety disorder is associated with restrictive eating disorder (fasting) in females, the rarity of fasting in male adolescents may reflect a difference in the presentation of disordered eating in males compared with females.	Mediation analysis was not conducted.	• Study demonstrates that in females, there is a predictive effect of anxiety disorders present in mid-adolescence on subsequent fasting behavior that is itself a risk factor for body weight changes. • Findings highlight anxiety disorder as a potential target for eating behavior disorder prevention.
11.	Micali et al. [2014]	• Overeating was associated with both emotional disorders. • Weight and shape concern and weight control behavior (WCB) were not associated with emotional disorders and were negatively associated with behavioral disorders. • In girls, bingeing/overeating were strongly associated with higher BMI z-scores at 15 years of age; that is, a 1-SD increase in the bingeing/overeating score corresponded to an expected 24 increase in BMI z-score. A similar strong association was seen in boys.	Mediation analysis was not conducted.	• Eating disorder (ED) cognitions are common among young teenage girls. Eating disorder symptoms have adverse cross-sectional and distal consequences, especially on increasing body weight 2 years later and on emotional disorders. These findings have important implications for the early identification of adolescents engaging in ED behaviors and for obesity prevention.
12.	Micali et al. [2015]	• Adolescents with anorexia nervosa (AN) were more likely to have later depression and anxiety disorders. • Those with bulimia nervosa (BN) had higher odds of reporting depression, anxiety disorders, and deliberate self-harm (DSH) compared with adolescents with no eating disorder (ED).	Mediation analysis was not conducted.	• This study strongly suggests that adolescent eating disorders, across the spectrum and independent of the frequency of behaviors, are associated with later adverse psychopathology and weight outcomes. Targeting adolescents with eating disorders and eating disorder behaviors in the community, first by improving identification and then by delivering low-

(Continues)

TABLE 2 (Continued)

s/n	First author [publication year]	Main findings	Study conducted EBRB mediation assessment	Conclusion
		• Subthreshold BN and purging disorder (PD) were prospectively associated with anxiety disorders, and DSH and binge eating disorder (BED) were associated with later depression and anxiety disorders. • Subthreshold BED was similarly associated with depression, anxiety disorders, and DSH. • Adolescents with AN were likely to remain underweight in the following wave. In contrast, adolescents with BED and BN had higher odds of living with obesity compared with adolescents without ED. These findings indicate that both full and subthreshold ED were strongly associated with later adverse mental health outcomes.		intensity early intervention programs, might lead to high public health benefits.
13.	Mougharbel et al. [2020]	• Greater TV viewing at T1 predicted higher z-BMI at T3. • Greater time spent playing video games at T1 was non-significantly associated with a higher z-BMI at T3. Further, time spent playing video games at T1 was non-significantly associated with restrained or emotional eating at T2. • Restrained eating at T2 was positively associated with z-BMI at T3.	Mediation analysis was not conducted.	• TV viewing was longitudinally associated with a higher z-BMI in a community-based sample of adolescents. Findings suggest that targeting a reduction in youth's TV viewing may be an effective component in the prevention of childhood obesity.
14.	Puterman et al. [2016]	• Higher stress was significantly related to a greater growth in BMI. • Higher stress predicted greater BMI growth than at lower levels of stress. At average activity, higher stress predicted greater BMI growth than lower stress. • Greater physical activity was significantly related to slower growth. • The relationship between cumulative stress and BMI growth varied at varying levels of physical activity. • These findings add to a converging literature suggesting that physical activity moderates the relationship between stress and poor physical outcomes.[55–59] For high-stress girls, those who reported moderate or higher levels of activity during the 10 years of the study had lower BMI growth compared with the girls who were more inactive, suggesting a possible threshold for activity at which	Mediation analysis was not conducted.	• In girls who maintained long-term activity, BMI growth was mitigated, even when reporting high long-term stress, compared with less physically active girls. This study adds to the converging literature in which physical activity, a modifiable prevention target, functions to potentially limit the damaging physical health effects of long-term psychological stress.

TABLE 2 (Continued)

s/n	First author [publication year]	Main findings	Study conducted EBRB mediation assessment	Conclusion
		its stress-buffering benefits are held steady when surpassed.		
15.	Rosenthal et al. [2015]	• Greater experiences of weight- and race-based bullying (stressors) were indirectly associated with increased BMI as well as decreased overall self-rated health across 2 years among predominantly Black and Latino, socioeconomically disadvantaged adolescents, through the mechanism of greater emotional symptoms even after EBRB variables like physical fitness and healthy and unhealthy eating were controlled for. • Stigmatization is a stressor that can affect mental health and, through that mechanism, affect physical health (e.g., BMI).	Emotional symptoms were assessed as mediators, but EBRBs were not reported as mediating the mental health-obesity relationship.	• Through the mechanism of greater negative emotional symptoms (mental health conditions), both weight- and race-based bullying (stigmatization/stressors) are indirectly associated with BMI as well as decreased overall self-rated health across 2 years among an at-risk sample of urban adolescents (Black and Latino–Americans).
16.	Solmi et al. [2018]	• There was no evidence of an association between psychotic experiences and greater excessive exercise and BMI at age 18 years. • Compared with those who had not had psychotic experiences, children with psychotic experiences at age 13 years had 1.5 times the risk of reporting any disordered eating behaviors in late adolescence. They were also more likely to report more disordered eating behaviors. • Psychotic experiences at age 13 years were prospectively associated with binge eating, fasting, and purging.	Mediation analysis was not conducted.	• Increased disordered eating behaviors, especially cycles of binge-eating and fasting, could partly account for increased rates of metabolic abnormalities in individuals with psychotic illness. • Psychotic experiences in early adolescence were longitudinally associated with disordered eating behaviors at age 18 years.

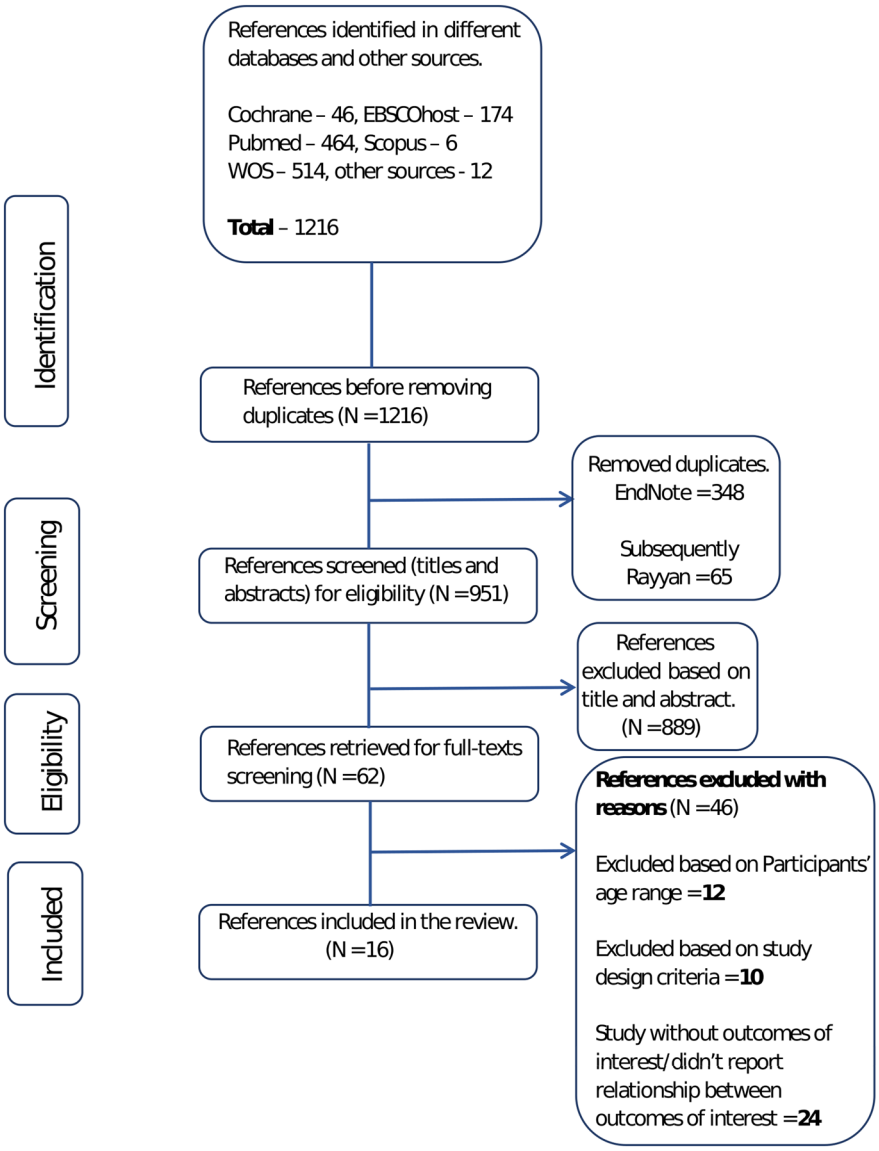

FIGURE 1 Preferred reporting items for systematic review and meta-analysis (PRISMA) flow chart for literature search outcome and inclusion strategy for a review on the longitudinal relationship between adolescents' broad mental health, energy balance-related behaviors (EBRBs), and body anthropometric changes.

3.7 | Relationship between mental health and anthropometry

Eleven out of the 16 included studies reported direct relationships between mental health measures and body anthropometric changes.[61,63–65,67–71,73,74] Those that reported direct relationships showed that poorer mental health measured by depression, anxiety, psychological distress, and perceived stress variables was longitudinally associated with an increase in body weight over time.

Most relationships were found between anxiety disorder or depression[64,65,67,68] and body mass indices derivatives, waist circumference, or body fat mass as body weight outcomes.[61,64,65,70] Most of the included studies are consistent that mental health and body anthropometry share a relationship over a time period of 10–19 years.[61,63–65,67–71,73,74] The relationships were reported to vary by adolescents' sex in some of the studies.[64,67,68,70,73] For example, Felton et al.[67] reported that the relationship between depression scores and changes in body fat was significant ($p < 0.05$) for girls but not for boys. In addition, two studies investigated only girls.[41,51]

3.8 | Relationship between mental health and EBRBs

Nine studies[28,66–69,71,72,75] reported relationships between mental health measures and EBRB outcomes. Precisely, a decline in mental health was associated with an increase in unhealthy EBRB choices, while improved mental health was related to healthier EBRB-choices. Felton et al.[67] and Clark et al.[28] reported that higher depression scores and symptoms, psychological distress, and negative body image were associated with unhealthy eating attitudes and health-risk behaviors, while Faulkner et al.[66] reported that positive mental health and flourishing had strong positive associations with quality and

longer sleep duration, as well as increased physical activity. Mental health conditions like anxiety disorders and depression were predictive of later eating disorder behaviors, including fasting behavior, anorexia nervosa, bulimia nervosa, and purging behaviors.[69,72]

One study reported on the impact of EBRB changes on mental health measures over time. Hoare et al.[68] showed that an increase in take-away food consumption over 2 years significantly predicted depressive symptoms at follow-up, irrespective of baseline depression symptoms.

3.9 | Mediating effect of EBRB on the relationship between mental health and anthropometry

Two studies reported on the mediation effects of EBRBs on the relationship between mental health and anthropometry.[65,73] Specifically, Chang et al.[65] reported that the effect of depressive symptoms on increased BMI was mediated by sleep problems, where higher levels of depressive symptoms were associated with more sleep problems and a higher BMI. Côté-Lussier et al.[73] reported that physical activity and screen time mediate the relationship between peer victimization (a mental health stressor) and the risk of adolescents' obesity over time.

Six studies[63,67–69,71,75] reported on the relationship between EBRB outcomes and the mental health–body anthropometry longitudinal dyad without directly assessing the mediating role of EBRB.

Puterman et al.[63] showed that healthy behaviors like physical activity could alleviate the effects of long-term psychological stress—overweight and obesity. Specifically, high-stressed girls who maintained physical activity over time consequently had lower stress levels and slower BMI increases compared with inactive girls. In contrast, behaviors related to eating disorders are linked with poorer mental health,[69,72,75] which was linked to an increase in body anthropometry.[71] In adolescents with psychosis, disordered eating behaviors such as binge eating and fasting partly accounted for the increased rate of metabolic abnormalities related to body anthropometry in later adolescence.[75] Rosenthal et al.,[74] however, reported that stressors like race- and weight-based bullying as well as stigmatization affected mental health and consequently affected BMI even after controlling for EBRBs like physical fitness and healthy and unhealthy eating among Latino and Black adolescents.

4 | DISCUSSION

To our knowledge, previous studies and reviews were focused on the cross-sectional relationship between adolescents' mental health and body weight without a clear understanding of the long-term relationship between these variables. To our knowledge, this is the first systematic review that aims to summarize the main findings from primary studies on the longitudinal relationship between adolescents' positive and negative mental health and body weight changes, as well as the role of EBRBs in this relationship. We identified 16 studies that met the inclusion criteria. Most studies showed a positive longitudinal relationship between various measures of adolescents' mental health and body anthropometry outcomes, or EBRBs, where poorer mental health was longitudinally associated with an increase in body weight or higher reporting of unhealthy EBRBs, respectively. The relationships between mental health and anthropometry, or mental health and EBRB, were found to be bidirectional. Furthermore, only two studies used mediation analyses and reported that the relationship between mental health and anthropometry was mediated by physical activity, screen time, and sleep problems.

4.1 | Adolescents' mental health and body weight change relationship

Most (11 out of 16) of the included studies confirmed a longitudinal relationship between mental health and body weight changes during adolescence. For example, Aparicio et al.[64] indicated that anxiety and depression around 10 years had a positive association with increased weight, adiposity, and waist circumference (related to fat distribution) at around age 13 years. Puterman et al.[63] reported that higher stress at age 10 years was significantly related to adolescents' increased BMI in subsequent annual follow-ups for 10 years. They implied that higher levels of stress predicted greater BMI growth than at lower levels of stress. Similarly, in late adolescence, higher perceived stress at baseline was associated with higher BMI and waist circumference after 1 year in 18-year-old males.[70] Hoare et al.[68] showed that male adolescents who were classified as having overweight or obesity at baseline and follow-up had higher depressive symptoms compared with male adolescents who were normal weight during the study period. This review of longitudinal studies confirms the results of cross-sectional studies that have indicated an association between mental health and body anthropometry in adolescents.[25,26] It is worth noting that there are few studies ($n = 5$) that did not identify a direct relationship between adolescents' mental health and anthropometric changes. The absence of a direct relationship may be linked to insufficient sample sizes,[72] a short time period used to assess mental health impact,[28,62,66] the validity of outcome measures for assessing this relationship,[75] the presence of cofounding covariates,[72,75] and a lack of focus on positive mental health variables such as adolescents' well-being and flourishing[66] because most studies are finding stronger associations with negative mental health, for example, anxiety, psychosis, and emotional disorders.[72,74]

Cross-sectional findings reported greater depressive symptoms and higher overall depression scores in youths with obesity when compared with youths with overweight or normal weight.[25] BeLue et al.[26] showed that in comparison with youth that are not overweight, both white and Hispanic youth who are overweight have a greater likelihood of reporting depression, anxiety, and general poor mental health. Hence, this review shows that the relationship between mental health and body weight found in cross-sectional studies is also observed in the long term and that this relationship is bidirectional.

Adolescents' sex plays a role in the long-term relationship between mental health and their body weight.[64,66,67,70,73] Aparicio

et al.[64] reported that the positive relationship between anxiety and depression among adolescents, and body weight, adiposity, and the distribution of abdominal fat was more predominant among males. Perceived stress by adolescents at baseline was shown to be associated positively in boys and negatively in girls with anthropometric and body composition outcomes.[70] Depression was related to weight gain for girls and weight loss for boys.[67] The reason for this variation may be linked to pubertal changes in adolescents' physiology. In girls, an increase in adipose tissue leading to increased body weight draws them away from the ideal body, while in boys, there is an increase in muscle mass among boys, thus becoming more in line with the muscular body ideal. Perceived or actual body image has major implications for mental health among adolescents because of pressure from peers, parents, and society.[76,78] There is still insufficient data to draw conclusions on the impact of sex on this long-term relationship between mental health and weight among adolescents.

One of the included studies highlighted the role of age in the relationship between mental health and adolescents' body weight changes.[67] Felton et al.[67] reported that depression scores were related to weight gain for older adolescents but not for younger adolescents. These findings confirm that the impact of mental health on body weight may be stronger in late adolescence. We suspect that this stronger association occurs in later adolescence because the impact of adolescents' mental health on body anthropometry is not immediate but rather a delayed consequence that builds up over time and coincides with the later years of adolescence.

4.2 | Adolescents' mental health–body weight dyad and EBRB mediation

Only two studies reported that specific EBRBs—sleep problems, screen time, and physical activity—mediate the relationship between adolescents' mental health and body weight changes.[65,73] Côté-Lussier et al.[73] showed that in adolescents experiencing psychological distress related to their mental health, weight-related behaviors like physical activities and time spent on the screen could be impacted, which further precedes the development of unhealthy weights. Chang et al.[65] further showed that increased depressive symptoms were linked to higher BMI through the mediating pathways of peer victimization (adolescent stressor) and sleep problems (EBRB). One intervention study by Puterman et al.[63] reported that among girls with high stress levels, moderate and higher levels of physical activity during the 10 years of the study were related to lower BMI growth compared with the girls who were more inactive. They further suggested that at a given high stress level, there may be a possible threshold at which physical activity may be beneficial for body weight over time. Furthermore, studies showed that other factors may contribute to this relationship, including stressors unique to adolescents, for example, pressure related to body- and self-perception,[67,78] victimization, and bullying.[65,73,74]

The review further showed that peer victimization in school could be associated with long-term depressive symptoms through sleep problems,[65] longer screen time, and a greater risk of higher BMI in boys.[73] These findings were supported by Kern et al.,[79] who reported that stressors like the perception of change in body size among adolescents were linked to psychopathologies and unhealthy EBRB, which may precede actual body weight changes. Previous cross-sectional studies also showed that unique EBRB combinations were associated with unfavorable weight status among young people.[24,80,81]

Adolescents can also respond to not meeting the ideal body goal by engaging further in poor dietary (binge eating and alcohol consumption, substance abuse) and less physical activity behaviors like longer screen time.[28,69,71,73] Hoare et al.[68] showed that male adolescents who were classified as living with overweight or obesity at baseline in their study were more likely to still be overweight and reported increased depressive symptomology at follow-up. The study emphasized addressing diet and physical activity as a foundation for addressing mental health and its impact on adolescents' body weight. This approach was implemented in Lemstra et al.,[77] where adolescents with obesity were placed on EBRB-based interventions to mitigate depression. They found that depressive symptoms and severe depressed mood were significantly reduced over the course of the intervention at both 12 and 52 weeks, respectively, which is then expected to reduce their BMI. The intervention was aimed at addressing both mental health conditions and obesity, signifying a possible mediating role of EBRB between poor mental health and body weight with time.

Several EBRBs were investigated in the included studies, and only two of the included studies conducted mediation analysis to assess whether EBRBs mediated the long-term relationship between mental health and body anthropometry during adolescence. This makes it difficult to conclude on the mediation of the mental health–body weight change relationship by EBRBs. In the meantime, focusing on the standard EBRBs will provide a basic and clearer understanding of the impact of EBRBs on the dyad relationship.

An emerging reality from previous and current reviews, as well as others that ran concurrently with this, is the complexity of the relationship between adolescents' mental health and body weight, as well as the role of several mediators, including EBRB. Blanchard et al.'s review (reference in Supporting Information) highlighted the significant positive relationship between mental health variables, specifically depression symptoms and low body image with social media. Anxiety also mediated the relationship between social media exposure and dietary outcomes. Aguiar et al. (reference in Supporting Information) linked mental health-related factors of self-stigmatization and body dissatisfaction with youth obesity, stress, and harmful EBRB. Hence, interventions aimed at fostering positive body image may hold potential for breaking the vicious cycles and for improving adolescent mental health, diet, and physical activity, as well as preventing obesity.

5 | STRENGTHS AND LIMITATIONS OF THE REVIEW

The review is strengthened by its protocol, which was designed based on an initially identified gap. The conceptualization, methods, and

synthesis of the review followed the latest PRISMA systematic review checklist.[30,31] Decisions on how the review will progress were made earlier before implementation, with very minimal changes during the review to limit possible bias. Most of the review processes, like screening, quality assessment, and data extraction, were performed by two reviewers independently after discussion and agreeing on how decisions would be made. There were minimal discrepancies in an initial test between reviewers' output when checked before the actual screening, quality assessment, and data extraction, and such discrepancies were resolved through discussion. Most studies that met the eligibility criteria were overall rated moderate or strong on the quality assessment criteria.

Variations in exposure and outcome measures made meta-analyses of included studies non-viable because variable and study analyses were not comparable across studies. To ensure homogeneity in participants' inclusion criteria, studies were included if participants' age range is within the WHO defined adolescents' age range.[32] Hence, findings from studies whose upper age limit is above 19 years, with a lower limit within 10–19 years, were systematically excluded. No study was identified in low- and middle-income countries (LMICs) that met the inclusion criteria of this review; thus, the findings from this review and their implications may not apply in such countries. The review focused on findings that reported mental health measures preceding body anthropometric changes and less on mental health changes following body anthropometric outcomes. The review was not designed to address the effect size nor the clinical significance of the results but rather to summarize current findings in relation to adolescents' mental health and body anthropometry.

6 | CONCLUSION

The review was designed to systematically summarize the main findings of research that investigated the longitudinal relationship between mental health and anthropometry changes, as well as the mediating role played by EBRBs in this relationship in the adolescent cohort. The findings of this review indicate that poorer mental health is associated with higher gains in body weight and fat over a long-term period. Poorer mental health was also associated with unhealthy EBRBs; however, this relationship was bidirectional, with some of the studies reporting that healthy EBRBs may alleviate mental health conditions and improve body weight outcomes. In addition, based on the findings from the two eligible studies that conducted mediation analysis, this review notes that EBRBs may mediate the long-term effects of mental health on anthropometry. Future studies may investigate other mediators, such as biological mechanisms as well as behavioral interventions on the dyad.

The number of studies that investigated this longitudinal relationship is currently insufficient to make conclusive remarks and are conducted in well-resourced settings. Hence, the need for more longitudinal studies assessing the relationship between adolescents' mental health, EBRBs, and body weight changes, specifically in LMICs. Future studies may focus on streamlining mental health measures and body weight outcomes to assess this relationship. More longitudinal investigations focusing on standard EBRBs will provide clearer insight on their roles in the mental health–body weight relationship during adolescence.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest in relation to this review.

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REFERENCES

1. Patel V, Flisher AJ, Hetrick S, McGorry P. Mental health of young people: a global public-health challenge. *Lancet*. 2007;369(9569):1302-1313. doi:10.1016/S0140-6736(07)60368-7
2. Blakemore SJ. Adolescence and mental health. *Lancet*. 2019;393(10185):2030-2031. doi:10.1016/S0140-6736(19)31013-X
3. Byrne DG, Davenport SC, Mazanov J. Profiles of adolescent stress: the development of the adolescent stress questionnaire (ASQ). *J Adolesc*. 2007;30(3):393-416. doi:10.1016/j.adolescence.2006.04.004
4. Freedman DS, Khan LK, Serdula MK, Dietz WH, Srinivasan SR, Berenson GS. The relation of childhood BMI to adult adiposity: the Bogalusa Heart Study. *Pediatrics*. 2005;115(1):22-27. doi:10.1542/peds.2004-0220
5. World Health Organization (WHO). *Adolescent Obesity and Related Behaviours: Trends and Inequalities in the WHO European Region, 2002–2014: Observations from the Health Behaviour in School-aged Children (HBSC) WHO Collaborative Cross-national Study*. 2017. Accessed November 20, 2021. Source: https://www.euro.who.int/en/health-topics/disease-prevention/nutrition/publications/2017/adolescent-obesity-and-related-behaviours-trends-and-inequalities-in-the-who-european-region,-20022014
6. World Health Organization (WHO). *Obesity and Overweight*. 2022. Accessed April 6, 2023. Source: https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight
7. Hill JO, Wyatt HR, Peters JC. Energy balance and obesity. *Circulation*. 2012;126(1):126-132. doi:10.1161/CIRCULATIONAHA.111.087213
8. Hall KD, Farooqi IS, Friedman JM, et al. The energy balance model of obesity: beyond calories in, calories out. *Am J Clin Nutr*. 2022;115(5):1243-1254. doi:10.1093/ajcn/nqac031
9. Fatima Y, Doi SA, Mamun AA. Longitudinal impact of sleep on overweight and obesity in children and adolescents: a systematic review and bias-adjusted meta-analysis. *Obes Rev*. 2015;16(2):137-149. doi:10.1111/obr.12245
10. Romieu I, Dossus L, Barquera S, et al. Energy balance and obesity: what are the main drivers? *Cancer Causes Control*. 2017;28(3):247-258. doi:10.1007/s10552-017-0869-z

11. Mannan M, Mamun A, Doi S, Clavarino A. Prospective associations between depression and obesity for adolescent males and females-a systematic review and meta-analysis of longitudinal studies. *PLoS ONE*. 2016;11(6):e0157240. doi:10.1371/journal.pone.0157240
12. Tomiyama AJ. Stress and obesity. *Annu Rev Psychol*. 2019;70(1):703-718. doi:10.1146/annurev-psych-010418-102936
13. Tajik E, Zulkefli NAM, Baharom A, Minhat HS, Abd LL. Contributing factors of obesity among stressed adolescents. *Electron Physician*. 2014;6(1):771-778. doi:10.14661/2014.771-778
14. Hendricks G, Savona N, Aguiar A, et al. Adolescents' perspectives on the drivers of obesity using a group model building approach: a South African perspective. *Int J Environ Res Public Health*. 2022;19(4):2160. doi:10.3390/ijerph19042160
15. Savona N, Macauley T, Aguiar A, et al. Identifying the views of adolescents in five European countries on the drivers of obesity using group model building. *Eur J Public Health*. 2021;31(2):391-396. doi:10.1093/eurpub/ckaa251
16. World Health Organization (WHO). *The World Health Report: Mental Health: New Understanding, New Hope*. World Health Organization; 2001.
17. World Health Organization (WHO). *Mental Health Action Plan 2013-2020*. 2021. Accessed February 23, 2023. Source: https://www.who.int/publications/i/item/9789241506021
18. Alegría M, NeMoyer A, Falgàs Bagué I, Wang Y, Alvarez K. Social determinants of mental health: where we are and where we need to go. *Curr Psychiatry Rep*. 2018;20(11):95. doi:10.1007/s11920-018-0969-9
19. Gabr H, Baragilly M, Willis BH. Measuring and exploring mental health determinants: a closer look at co-residents' effect using a multilevel structural equations model. *BMC Med Res Methodol*. 2022;22(1):236. doi:10.1186/s12874-022-01711-9
20. Office of Populations Affairs (OPA). *Mental Health for Adolescents*. 2023. Accessed January 6, 2023. Source: https://opa.hhs.gov/adolescent-health/mental-health-adolescents
21. Adom T, De Villiers A, Puoane T, Kengne AP. School-based interventions targeting nutrition and physical activity, and body weight status of African children: a systematic review. *Nutrients*. 2020;12(1):95. doi:10.3390/nu12010095
22. Avila C, Holloway AC, Hahn MK, et al. An overview of links between obesity and mental health. *Curr Obes Rep*. 2015;4(3):303-310. doi:10.1007/s13679-015-0164-9
23. Burke NL, Storch EA. A meta-analysis of weight status and anxiety in children and adolescents. *J Dev Behav Pediatr*. 2015;36(3):133-145. doi:10.1097/DBP.0000000000000143
24. Inchley J, Currie D, Budisavljevic S, et al. Spotlight on adolescent health and well-being. Findings from the 2017/2018 Health Behaviour in School-aged Children (HBSC) survey in Europe and Canada. *Int Rep*. 2020;1.
25. Goldfield GS, Moore C, Henderson K, Buchholz A, Obeid N, Flament MF. Body dissatisfaction, dietary restraint, depression, and weight status in adolescents. *J Sch Health*. 2010;80(4):186-192. doi:10.1111/j.1746-1561.2009.00485.x
26. BeLue R, Francis LA, Colaco B. Mental health problems and overweight in a nationally representative sample of adolescents: effects of race and ethnicity. *Pediatrics*. 2009;123(2):697-702. doi:10.1542/peds.2008-0687
27. Conklin AI, Guo SX, Tam AC, Richardson CG. Gender, stressful life events and interactions with sleep: a systematic review of determinants of adiposity in young people. *BMJ Open*. 2018;8(7):e019982. doi:10.1136/bmjopen-2017-019982
28. Clark C, Haines MM, Head J, et al. Psychological symptoms and physical health and health behaviours in adolescents: a prospective 2-year study in East London. *Addiction*. 2007;102(1):126-135. doi:10.1111/j.1360-0443.2006.01621.x
29. Hoare E, Skouteris H, Fuller-Tyszkiewicz M, Millar L, Allender S. Associations between obesogenic risk factors and depression among adolescents: a systematic review. *Obes Rev*. 2014;15(1):40-51. doi:10.1111/obr.12069
30. Moher D, Shamseer L, Clarke M, et al. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. *Syst Rev*. 2015;4(1):1-9. doi:10.1186/2046-4053-4-1
31. Purssell E, McCrae N. *How to Perform a Systematic Literature Review: a Guide for Healthcare Researchers, Practitioners and Students*. Springer Nature; 2020. doi:10.1007/978-3-030-49672-2
32. World Health Organization (WHO). *Adolescent Health*. 2022. Accessed April 4, 2022. Source: https://www.who.int/health-topics/adolescent-health
33. Bramer WM, Giustini D, de Jonge GB, Holland L, Bekhuis T. De-duplication of database search results for systematic reviews in EndNote. *J Medi Library Assoc: JMLA*. 2016;104(3):240-243. doi:10.3163/1536-5050.104.3.014
34. McKeown S, Mir ZM. Considerations for conducting systematic reviews: evaluating the performance of different methods for de-duplicating references. *Syst Rev*. 2021;10(1):38. doi:10.1186/s13643-021-01583-y
35. Mourad O, Hossam H, Zbys F, Ahmed E. Rayyan—a web and mobile app for systematic reviews. *Syst Rev*. 2016;5(1):210. doi:10.1186/s13643-016-0384-4
36. Ciliska D, Miccouci S, Dobbins M. *Effective Public Health Practice Project. Quality Assessment Tool for Quantitative Studies*. Effective Public Health Practice Project; 1998.
37. Birmaher B, Khetarpal S, Brent D, et al. The screen for child anxiety related emotional disorders (SCARED): scale construction and psychometric characteristics. *J am Acad Child Adolesc Psychiatry*. 1997;36(4):545-553. doi:10.1097/00004583-199704000-00018
38. Kovacs M. The children's depression, inventory (CDI). *Psychopharmacol Bull*. 1985;21(4):995-998.
39. Cash TF, Szymanski ML. The development and validation of the Body-Image Ideals Questionnaire. *J Pers Assess*. 1995;64(3):466-477. doi:10.1207/s15327752jpa6403_6
40. Serra-Majem L, Aranceta-Bartrina J, Ribas-Barba L, Sangil-Monroy M, Pérez-Rodrigo C. Crecimiento y desarrollo: dimensión alimentaria y nutricional. El cribado del riesgo nutricional en pediatría. Validación del test rápido, Krece Plus y resultados en la población española. In: Serra-Majem L, Aranceta-Bartrina J, eds. *Crecimiento y desarrollo. Estudio Enkid. Krece plus*. Vol.4. Masson; 2003:45-55.
41. Román-Viñas B, Serra-Majem L, Ribas-Barba L, Pérez Rodrigo C, Aranceta-Bartrina J. Crecicimiento y desarrollo: actividad física. Estimación del nivel de actividad física mediante el Test Corto Krece Plus. Resultados en la población española. In: Serra-Majem L, Aranceta-Bartrina J, eds. *Crecimiento y desarrollo. Estudio Enkid. Krece Plus*. Vol. 4. Masson; 2003:57-74.
42. Crick NR, Grotpeter JK. Children's treatment by peers: victims of relational and overt aggression. *Dev Psychopathol*. 1996;8(2):367-380. doi:10.1017/S0954579400007148
43. Faulstich ME, Carey MP, Ruggiero L, Enyart P, Gresham F. Assessment of depression in childhood and adolescence: an evaluation of the Center for Epidemiological Studies Depression Scale for Children (CES-DC). *Am J Psychiatry*. 1986;143(8):1024-1027. doi:10.1176/ajp.143.8.1024
44. Buysse DJ, Reynolds CF III, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. *Psychiatry Res*. 1989;28(2):193-213. doi:10.1016/0165-1781(89)90047-4
45. World Health Organization (WHO). *Growth Reference 5–19 Years*. 2007. Accessed April 4, 2022. Source: https://www.who.int/growthref/who2007_bmi_for_age/en/
46. Diener E, Wirtz D, Tov W, et al. New well-being measures: short scales to assess flourishing and positive and negative feelings.

Soc Indicators Res. 2010;97(2):143-156. doi:10.1007/s11205-009-9493-y

47. Andresen EM, Malmgren JA, Carter WB, Patrick DL. Screening for depression in well older adults: evaluation of a short form of the CES-D. *Am J Prev Med*. 1994;10(2):77-84. doi:10.1016/S0749-3797(18)30622-6
48. Angold A, Costello EJ, Messer SC, Pickles A. Development of a short questionnaire for use in epidemiological studies of depression in children and adolescents. *Int J Methods Psychiatr Res*. 1995;5:251-262.
49. Cohen S, Kamarck T, Mermelstein R. A global measure of perceived stress. *J Health Soc Behav*. 1983;385-396(4):385. doi:10.2307/2136404
50. Goodman R, Ford T, Richards H, Gatward R, Meltzer H. The development and well-being assessment: description and initial validation of an integrated assessment of child and adolescent psychopathology. *J Child Psychol Psychiatry*. 2000;41(5):645-655. doi:10.1111/j.1469-7610.2000.tb02345.x
51. Onis MD, Onyango AW, Borghi E, Siyam A, Nishida C, Siekmann J. Development of a WHO growth reference for school-aged children and adolescents. *Bull World Health Organ*. 2007;85(9):660-667. doi:10.2471/BLT.07.043497
52. Maras D, Flament MF, Murray M, et al. Screen time is associated with depression and anxiety in Canadian youth. *Prev Med*. 2015;73:133-138. doi:10.1016/j.ypmed.2015.01.029
53. Ku LC, Shapiro LR, Crawford PB, Huenemann RL. Body composition and physical activity in 8-year-old children. *Am J Clin Nutr*. 1981;34(12):2770-2775. doi:10.1093/ajcn/34.12.2770
54. Obarzanek E, Schreiber GB, Crawford PB, et al. Energy intake and physical activity in relation to indexes of body fat: the National Heart, Lung, and Blood Institute Growth and Health Study. *Am J Clin Nutr*. 1994;60(1):15-22. doi:10.1093/ajcn/60.1.15
55. Haines J, Neumark-Sztainer D, Eisenberg ME, Hannan PJ. Weight teasing and disordered eating behaviors in adolescents: longitudinal findings from Project EAT (Eating Among Teens). *Pediatrics*. 2006;117(2):e209-e215. doi:10.1542/peds.2005-1242
56. Neumark-Sztainer D, Falkner N, Story M, Perry C, Hannan PJ, Mulert S. Weight-teasing among adolescents: correlations with weight status and disordered eating behaviors. *Int J Obes (Lond)*. 2002;26(1):123-131. doi:10.1038/sj.ijo.0801853
57. Hamer M. Psychosocial stress and cardiovascular disease risk: the role of physical activity. *Psychosom Med*. 2012;74(9):896-903. doi:10.1097/PSY.0b013e31827457f4
58. Puterman E, Adler N, Matthews KA, Epel E. Financial strain and impaired fasting glucose: the moderating role of physical activity in the coronary artery risk development in young adults study. *Psychosom Med*. 2012;74(2):187-192. doi:10.1097/PSY.0b013e3182448d74
59. Puterman E, Epel E. An intricate dance: life experience, multisystem resiliency, and rate of telomere decline throughout the lifespan. *Soc Personality Psychology Compass*. 2012;6(11):807-825. doi:10.1111/j.1751-9004.2012.00465.x
60. Shrivastava A, Johnston ME. Weight-gain in psychiatric treatment: risks, implications, and strategies for prevention and management. *Mens Sana Monographs*. 2010;8(1):53-68. doi:10.4103/0973-1229.58819
61. Kipp C, Wilson DK, Sweeney AM, Zarrett N, Van Horn ML. Effects of parenting and perceived stress on BMI in African American adolescents. *J Pediatr Psychol*. 2021;46(8):980-990. doi:10.1093/jpepsy/jsab025
62. Mougharbel F, Valois DD, Lamb M, et al. Mediating role of disordered eating in the relationship between screen time and BMI in adolescents: longitudinal findings from the Research on Eating and Adolescent Lifestyles (REAL) study. *Public Health Nutr*. 2020;23(18):3336-3345. doi:10.1017/S136898002000049X
63. Puterman E, Prather AA, Epel ES, et al. Exercise mitigates cumulative associations between stress and BMI in girls age 10 to 19. *Health Psychol*. 2016;35(2):191-194. doi:10.1037/hea0000258
64. Aparicio E, Canals J, Voltas N, Hernández-Martínez C, Arija V. Emotional psychopathology and increased adiposity: follow-up study in adolescents. *J Adolesc*. 2013;36(2):319-330. doi:10.1016/j.adolescence.2012.12.003
65. Chang LY, Chang HY, Wu WC, Lin LN, Wu CC, Yen LL. Body mass index and depressive symptoms in adolescents in Taiwan: testing mediation effects of peer victimization and sleep problems. *Int J Obes (Lond)*. 2017;41(10):1510-1517. doi:10.1038/ijo.2017.111
66. Faulkner G, Weatherson K, Patte K, Qian W, Leatherdale ST. Are one-year changes in adherence to the 24-hour movement guidelines associated with flourishing among Canadian youth? *Prev Med*. 2020;139:106179. doi:10.1016/j.ypmed.2020.106179
67. Felton J, Cole DA, Tilghman-Osborne C, Maxwell MA. The relation of weight change to depressive symptoms in adolescence. *Dev Psychopathol*. 2010;22(1):205-216. doi:10.1017/S0954579409990356
68. Hoare E, Millar L, Fuller-Tyszkiewicz M, et al. Depressive symptomatology, weight status and obesogenic risk among Australian adolescents: a prospective cohort study. *BMJ Open*. 2016;6(3):e010072. doi:10.1136/bmjopen-2015-010072
69. Micali N, Solmi F, Horton NJ, et al. Adolescent eating disorders predict psychiatric, high-risk behaviors and weight outcomes in young adulthood. *J am Acad Child Adolesc Psychiatry*. 2015;54(8):652-659. doi:10.1016/j.jaac.2015.05.009
70. Hootman KC, Guertin KA, Cassano PA. Stress and psychological constructs related to eating behavior are associated with anthropometry and body composition in young adults. *Appetite*. 2018;125:287-294. doi:10.1016/j.appet.2018.01.003
71. Micali N, Ploubidis G, De Stavola B, Simonoff E, Treasure J. Frequency and patterns of eating disorder symptoms in early adolescence. *J Adolesc Health*. 2014;54(5):574-581. doi:10.1016/j.jadohealth.2013.10.200
72. Lloyd EC, Haase AM, Zerwas S, Micali N. Anxiety disorders predict fasting to control weight: a longitudinal large cohort study of adolescents. *Eur Eat Disord Rev*. 2020;28(3):269-281. doi:10.1002/erv.2714
73. Côté-Lussier C, Fitzpatrick C, Séguin L, Barnett TA. Poor, unsafe, and overweight: the role of feeling unsafe at school in mediating the association among poverty exposure, youth screen time, physical activity, and weight status. *Am J Epidemiol*. 2015;182(1):67-79. doi:10.1093/aje/kwv005
74. Rosenthal L, Earnshaw VA, Carroll-Scott A, et al. Weight-and race-based bullying: health associations among urban adolescents. *J Health Psychol*. 2015;20(4):401-412. doi:10.1177/1359105313502567
75. Solmi F, Melamed D, Lewis G, Kirkbride JB. Longitudinal associations between psychotic experiences and disordered eating behaviours in adolescence: a UK population-based study. *Lancet Child Adolescent Health*. 2018;2(8):591-599. doi:10.1016/S2352-4642(18)30180-9
76. Byrne NM, Hills AP. Should body-image scales designed for adults be used with adolescents? *Percept Mot Skills*. 1996;82(3):747-753. doi:10.2466/pms.1996.82.3.747
77. Lemstra M, Rogers M. The short and long-term impact of the healthy kids initiative on depressed mood in youth living with obesity. *Obes Res Clin Pract*. 2022;16(5):393-399. doi:10.1016/j.orcp.2022.08.004
78. Lankinen V, Fröjd S, Marttunen M, Kaltiala-Heino R. Perceived rather than actual overweight is associated with mental health problems in adolescence. *Nord J Psychiatry*. 2018;72(2):89-96. doi:10.1080/08039488.2017.1389987
79. Kern MR, Duinhof EL, Walsh SD, et al. Intersectionality and adolescent mental well-being: a cross-nationally comparative analysis of the interplay between immigration background, socioeconomic status and gender. *J Adolesc Health*. 2020;66(6):S12-S20. doi:10.1016/j.jadohealth.2020.02.013

80. Bel-Serrat S, Ojeda-Rodríguez A, Heinen MM, et al. Clustering of multiple energy balance-related behaviors in school children and its association with overweight and obesity—WHO European childhood obesity surveillance initiative (COSI 2015–2017). *Nutrients*. 2019; 11(3):511. doi:10.3390/nu11030511
81. Burns RD. Energy balance-related factors associating with adolescent weight loss intent: evidence from the 2017 National Youth Risk Behavior Survey. *BMC Public Health*. 2019;19(1):1206. doi:10.1186/s12889-019-7565-8

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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