Association Between Childhood Maltreatment and Weight Status in Young People: Considerations of Inhibitory Control and Depression

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Thesis Portfolio Abstract

Background: Childhood maltreatment is linked to obesity in adulthood, however, evidence of this association in children and adolescents remained mixed. The association may vary by maltreatment type and gender or be mediated by factors such as depressive symptoms and inhibitory control. Clarifying this relationship in youth is crucial for early identification and intervention.

Methods: This portfolio comprises two interconnected studies. The first is a systematic review and meta-analysis investigating the strength of association between childhood maltreatment and obesity in individuals aged 25 and under. The second is an empirical cross-sectional study exploring this association in a United Kingdom community sample, and the potential mediating roles of inhibitory control and depressive symptoms.

Results: The meta-analysis found that the association between maltreatment and obesity varied by subtypes, with significant associations found for sexual abuse. The empirical study found a general positive correlation between combined maltreatment and standardised Body Mass Index (zBMI; BMI-for-age-and-sex z-score) and Body Mass Index (BMI; kg/m^2) in adolescents and young adults. Childhood maltreatment did not predict zBMI/ BMI when controlling for depressive symptoms in both age groups. Neither depressive symptoms nor inhibitory control mediated the relationship. Socioeconomic status, however, was a significant predictor of BMI in young adults.

Conclusion: These findings highlight the importance of multidimensional approaches in understanding the relationship between childhood maltreatment and weight outcomes in research and clinical work.

Chapter One: Introduction to the Thesis Portfolio

Childhood maltreatment, which typically includes physical, sexual, and emotional abuse, as well as neglect, is a major public health issue with lasting effects on mental, emotional, and physical well-being (Gilbert et al., 2009). Although related to the broader category of Adverse Childhood Experiences (ACEs), childhood maltreatment represents a specific and more direct form of harm that often requires distinct investigation. It has been consistently linked to mental health difficulties such as depression, anxiety, and aggression (Brown et al., 2017; Lee & Hoaken, 2007), as well as substance misuse and eating disorders (Fosse & Holen, 2006; Lo & Cheng, 2007). Physical health problems, including obesity, have also been associated with childhood maltreatment (Danese & Tan, 2014; Heim et al., 2009). Given the complex interplay between mental and physical health, understanding the relationship between childhood maltreatment and weight outcomes is critical for informing targeted interventions.

Association between Childhood Maltreatment and Weight Outcomes

A meta-analysis by Danese and Tan (2014) found that adults with a history of childhood maltreatment had a significantly higher risk of obesity (OR = 1.38, 95% CI [1.28, 1.50]). However, this association was not statistically significant in children and adolescents (OR = 1.13, 95% CI [0.92, 1.39]), possibly due to the limited number of studies available. Only nine studies were available for the younger population. More recent systematic review and meta-analysis studies have reported an association between ACEs and childhood obesity (Elsenburg et al., 2017; Schroeder et al., 2021). For instance, Schroeder et al. (2017) found that ACEs increased the risk of obesity in children. However, the qualities of these reviews varied, with limitations such as small sample sizes and potential measurement biases. Importantly, ACEs include a

broader range of experiences beyond maltreatment, such as parental substance use and divorce. As such, findings based on ACEs cannot be assumed to directly reflect the impact of childhood maltreatment alone. An updated systematic review and meta-analysis focused specifically on the common types of maltreatment and childhood obesity is therefore warranted.

Considerations of Maltreatment Subtypes

Emerging research suggests that the relationship between childhood maltreatment and childhood obesity may vary by maltreatment subtype and gender. Schneiderman (2015) reported a significant association between sexual abuse/neglect and Body Mass Index (BMI) in girls. In contrast, Noll (2007) found no such association for sexual abuse. In another study, Jun et al. (2012) identified a relationship between domestic violence and BMI in boys, though the nature of the violence was unspecified. These mixed findings underscore the need to account for both maltreatment type and gender when examining the relationship between childhood maltreatment and weight outcomes.

The Role of Inhibitory Control and Depression in Childhood Maltreatment and Weight Outcomes

Investigating the mediators of the association between childhood maltreatment and weight outcomes is essential for uncovering underlying mechanisms. Two key factors that may influence these associations are depressive symptoms and inhibitory control. Childhood maltreatment has been consistently linked to increased risk of depression (Humphreys et al., 2021) and depression itself shows a bidirectional relationship with obesity (Luppino et al., 2010; Park et al., 2025). A prior meta-analysis by Danese and Tan (2014) also suggested that

depressive symptoms may mediate the relationship between childhood maltreatment and obesity.

Inhibitory control, a core executive function, reflecting the ability to suppress impulsive behaviour has also been implicated. Childhood maltreatment has been associated with heightened impulsivity (Liu et al., 2019), while low inhibitory control has been linked to weight gain and high inhibitory control to weight loss (De Klerk et al., 2023). Evidence from the Stop-Signal Paradigm supports the predictive value of inhibitory control on weight outcomes in both adolescents and adults (Kulendran et al., 2017). Furthermore, two meta-analyses (Allom et al., 2016; Jones et al., 2016) found that the Go/No-Go Paradigm had a stronger effect size than the Stop-Signal Paradigm in influencing eating behaviour, suggesting that it may be a more effective behavioural measure for assessing the mediating role of inhibitory control in the relationship between childhood maltreatment and weight outcomes.

The Present Thesis Portfolio

This thesis portfolio comprises two interconnected components. The first is a systematic review and meta-analysis that synthesises existing studies on the relationship between childhood maltreatment and weight status in individuals up to the age of 25. The second is an empirical study that examines this association further, exploring the potential mediating roles of inhibitory control and depressive symptoms using a community sample of youth in the United Kingdom. Individuals up to the age of 25 were included to capture both adolescence and emerging adulthood, representing a critical neurodevelopmental period marked by continued development in executive functioning, psychosocial reasoning, and health-related behaviours.

Chapter Two: Systematic Review and Meta-Analysis

Association between childhood maltreatment and obesity in young people: a systematic review and meta-analysis

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Abstract

Background: The present systematic review and meta-analysis examined the association between common types of childhood maltreatment and obesity in individuals up to 25 years of age. Methods: A comprehensive search across Medline, PsycInfo, and Embase identified 2 472 studies, of which 17 met the eligibility criteria for meta-analysis. Random-effect meta-analyses were conducted for each maltreatment subtype where five or more studies were available. Two sets of sensitivity analyses were conducted to account for outliers and effect size transformations. Results: In the primary analyses, sexual abuse was associated with higher odds of obesity (OR = 1.31, 95% CI [1.01, 1.70]), whereas combined maltreatment, physical abuse, emotional abuse, and combined neglect were not. In sensitivity analyses excluding outliers, the association for sexual abuse persisted (OR = 1.37, 95% CI [1.07, 1.75]) and an association for combined neglect emerged (OR = 1.21, 95% CI [1.03, 1.42]). These associations were largely unaffected by study characteristics including publication year, age group, study quality, or study design. Conclusions: Findings highlight the importance of considering maltreatment subtypes when examining early-life risk factors for obesity.

Introduction

Obesity is a major public health concern, associated with increased risk of chronic diseases such as Type 2 diabetes, cardiovascular diseases and psychological disorders, which in turn can lead to higher rates of mortality and poorer quality of life. According to the Health Survey for England, 29% of adults aged 16 and over were living with obesity, and 64% were either overweight or living with obesity.[1] Among children aged 2 to 15, 15% were living with obesity, and 27% were either overweight or living with obesity. Its prevalence was the highest among adults and children living in the most deprived areas. NHS England spends £6.5 billion a year on treating obesity-related health conditions, positing significant socioeconomic cost to the country. These findings underscore the importance of understanding the underlying risk factors contributing to obesity and overweight that go beyond traditional determinants such as nutrition and physical activity.

Childhood maltreatment, encompassing physical, emotional, and sexual abuse as well as neglect, affects a significant portion of the global population, with approximately one in five children in the UK have experienced severe maltreatment.[2] Beyond its immediate psychological impact, childhood maltreatment has also been linked to long-term health consequences, such as obesity. A review of 41 studies by Danese and Tan[3] found evidence of a significant association between childhood maltreatment and obesity in adults (OR = 1.36, 95% CI [1.26, 1.47]). In contrast, the association was statistically non-significant in studies examining children and adolescents (OR = 1.13, 95% CI [0.92, 1.39]). The authors hypothesised an incubation period between the exposure to childhood maltreatment and biological outcomes, whilst acknowledging the limited number of studies on children and adolescents (k = 8) in the review.

Furthermore, they found that the association between childhood maltreatment and adult obesity became statistically non-significant after adjusting for depression, suggesting depression may mediate this association.

Using a systematic review and meta-analysis, Elsenburg et al[4]. reviewed 18 studies to investigate the relationship between the accumulation of adverse life events and measures of being overweight in children and adolescents. Focusing on several observational and case-control studies, they found that individuals who experienced Adverse Childhood Experiences (ACEs) had 1.12 times greater odds of being overweight. Similarly, Schroeder et al.[5] conducted a systematic review of 24 studies, which found evidence that ACEs were positively associated with childhood obesity. Their synthesis further revealed that sexual abuse and the co-occurrence of multiple ACEs had a greater impact on childhood obesity than other forms of ACEs. Although effect sizes were considered in their review, these effect sizes were not quantitatively synthesised, limiting the ability to quantify the overall magnitude of the association.

The inconsistencies between these published reviews may stem from differences in study methodology. For example, Danese and Tan[3] prioritised extracting data on physical abuse when multiple effect sizes were available within individual studies. Another potential source of variation is the differing definitions of childhood maltreatment across studies. Previous reviews[3,4,5] often incorporated broader adverse childhood experiences, such as parental divorce or family substance use, alongside the five specific forms of childhood maltreatment defined by the World Health Organization (physical abuse, sexual abuse, emotional abuse, neglect,

exploitation).[6] This variability complicates direct comparisons across studies and may influence observed associations.

Emerging evidence suggests that the relationship between childhood maltreatment and obesity may vary depending on the type of maltreatment experienced. For instance, Hawton et al.[7] found associations between physical and emotional abuse and obesity, while Schneiderman et al.[8] reported significant associations between sexual abuse and neglect with higher Body Mass Index (BMI) in girls. Conversely, Noll[9] did not find a significant link between sexual abuse and BMI. These mixed findings underscore the importance of examining individual forms of maltreatment when investigating their potential connections to obesity. Finally, the association between childhood maltreatment and obesity in young people is likely influenced by confounding factors such as depression, as highlighted by Danese and Tan.[3]

This review aimed to clarify the relationships between childhood maltreatment subtypes and obesity risk by synthesising research findings involving young people up to 25 years of age, while accounting for confounding factors like depression. Key contributions include focusing on a critical developmental period for potential early obesity prevention, providing clear estimates of the strength of association, and encouraging further investigation of underlying mechanisms.

Method

Protocol and Registration

The study protocol was registered with PROSPERO (ID: CRD42024493363) on 3 January 2024 and adheres to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines.[10]

Search Strategy

We searched Medline, PsycINFO and Embase databases to identify studies related to childhood maltreatment and obesity (search terms: child* maltreatment OR child* abuse OR child*neglect OR family conflict) and obesity (search terms: obesity OR overweight OR body-mass index OR BMI or body size OR adiposity OR waist circumstances) in children and adolescents (search terms: adolescents OR teenagers OR young adults OR teen OR youth OR child). The search terms were a replication of Danese and Tan's[3] paper to ensure methodological consistency and facilitate direct comparison with earlier published findings. The search was run by "Abstract and Title", keywords, and Medical Subject headings. We limited our search to human studies published in English published by 10 Oct 2024.

Study Selection

Titles and abstracts were screened by the first author (AH) to remove duplicates and assess relevance based on predetermined inclusion and exclusion criteria. Selected articles underwent full-text screening, with a randomly selected 25% of these studies independently reviewed by the fourth author (HC). Disagreements between reviewers at each screening stage were discussed and resolved by consensus.

In this meta-analysis, peer-reviewed quantitative studies that meet the following criteria were included: (1) participants were aged up to 25 years; (2) studies assessed one or more types of childhood maltreatment (including physical abuse, sexual abuse, emotional abuse, neglect, and witnessing domestic violence before the age of 18) using psychometric measures or clinical records; (3) obesity was defined either categorically or continuously using Body Mass

Index (BMI; kg/m²) for those aged 18 or above and standardised Body Mass Index (zBMI; BMI-for-age-and-sex z-score) for those under the age of 18; (4) childhood maltreatment preceded the onset of obesity; (5) employed cross-sectional or longitudinal study design; (6) the relationship between childhood maltreatment and obesity can be quantified using odds ratios.

Studies were excluded from the review if they (1) were non peer-reviewed (e.g. dissertations, preprints, conference abstracts), as peer review serves as a marker of methodological and theoretical quality; (2) were clinical trials/ intervention studies, as our aim was to synthesis and naturalistic associations, and inclusion would introduce heterogeneity from treatment effects, programme components, and selective service engagement that limits comparability across studies; (3) measured childhood adversity only (e.g., bullying in school, parental substance use, household dysfunction) rather than childhood maltreatment; (4) focused on clinical or treatment-seeking samples (e.g., patients with eating disorders or post-traumatic stress disorder) as these populations may present elevated levels of psychopathology or treatment-related effects that could bias results and limit the generalisability of findings to the general population; (5) studies using datasets previously analysed in other studies included in this review. We note that excluding intervention and treatment-seeking samples may bias the included evidence toward non-clinical and subclinical populations.

Data Extraction

Data extracted from each study included: (1) study details (e.g. title, authors, year of publication, country), (2) study design (i.e. cross-sectional, longitudinal), (3) demographic information (e.g. age, gender, ethnicity), (4) maltreatment measures (e.g. questionnaires,

clinical records), (5) type of maltreatment, (6) obesity-related measures (e.g. categorical, BMI, waist circumference) and (7) covariates considered in the adjusted effect sizes (e.g. socioeconomic status, depression).

Effect Size Calculation

We extracted adjusted effect sizes whenever possible for each type of maltreatment and stratified them by gender when multiple effect sizes were reported. We considered combined categories of overweight and obesity and treated BMI as a continuous variable when obesity categorical data was not available. We sought to extract odds ratios primarily. When studies reported beta coefficients, we converted these to correlation coefficients.[11] When studies reported correlation coefficient (*r*), we converted them to odds ratios for our analyses. Since odds ratios consider dichotomous outcomes while *r* typically considers continuous outcomes, we conducted a meta-analysis excluding the *r* coefficients that have been converted to odds ratios as a sensitivity analysis.

Study Quality Assessment

To ensure a systematic assessment across studies with varying designs, a quality assessment tool was adapted based on the Quality Appraisal Checklist for Studies Reporting Correlations and Associations[12] and the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement[13]. It assessed four areas: sample representativeness, appropriateness of sampling and recruitment methods, non-response bias, and reliability of

measures for childhood maltreatment (see Table S1). Each criterion was scored on a binary scale (*yes* = 1, *no* = 0), with higher scores indicating greater study quality or a lower risk of bias.

The first author (AH) conducted the initial ratings for all included studies. To evaluate inter-rater reliability, the fourth author (HC) independently rated a random 25% subset. To assess the inter-rater reliability, intraclass correlation coefficient was computed based on the item-level ratings. Any discrepancies were resolved through discussion.

Meta-Analytic Method

Random-effects meta-analyses were performed using "*meta*" (version 8.0.2)[14] in R version 4.4.0.[15] We focused on different subtypes of maltreatment, including combined abuse, physical abuse, sexual abuse, emotional abuse, and combined neglect. Combined abuse referred to a history of maltreatment without specifying specific types, such as studies that reported an integrated score based on childhood maltreatment measures. Combined neglect encompassed both physical and emotional neglect. In addition, we included studies involving individuals who had witnessed domestic abuse, as this was a common experience among maltreated individuals.[16]

Meta-analyses were conducted when at least five studies were available for each maltreatment type.[17] This stage was referred to as "Analysis Phase A" in this study.

The heterogeneity of effect sizes was indicated by the I^2 statistic,[18] where I^2 value of 25%, 50%, and 75% represent small, moderate, and large degree of heterogeneity respectively.[19] In line with recommendations by IntHout et al.,[20] 95% prediction intervals (PIs) were reported to aid interpretation of heterogeneity and provide an estimate of the range within which future study

effects may fall, accounting for between-study variation. Study heterogeneity was explored using subgroup moderation analyses. Categorical moderators (maltreatment measure, study design, obesity measure, obesity definition) were conducted if at least ten studies were included in the meta-analysis and subgroups had at least four observations. [21, 22] Study quality score was used as a continuous moderator to investigate the impact of study quality on the effect sizes reported. Gender was not prespecified as a moderator. The primary aim of the study was to synthesise odds ratios by maltreatment subtype, and we restricted moderator analyses to variables for which comparable effect sizes were available across studies. Funnel plots and the Egger's test were performed to assess publication bias if more than 10 studies available in a single meta-analysis. [23, 24]

Sensitivity Analyses

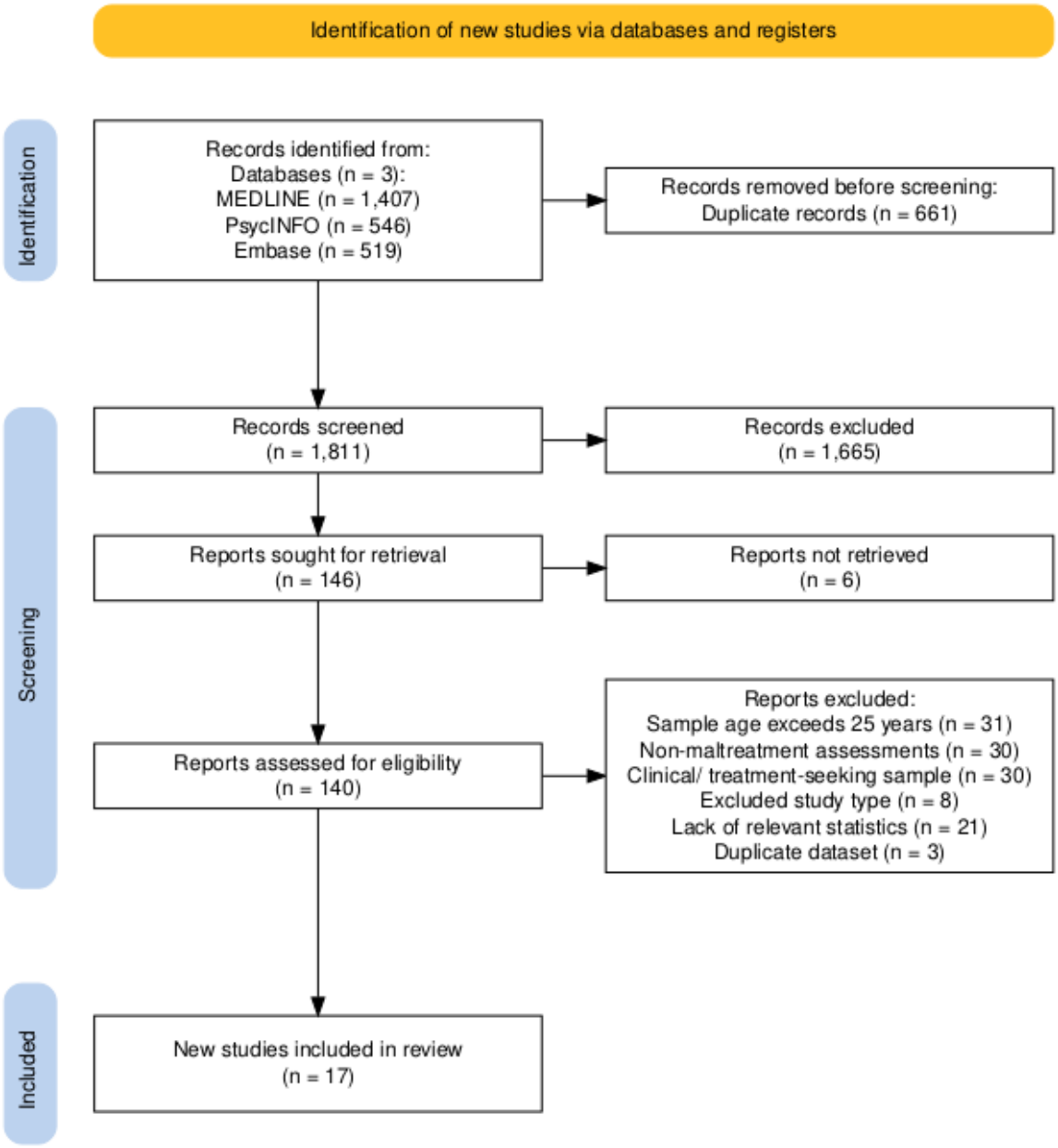
Two sets of sensitivity analyses were performed. The first set focused on identifying and managing outliers, while the second examined the transformation of effect sizes. These are referred to as "Analysis Phase B and C" in this analysis. To identify outliers, we utilised the "*find.outliers*" function from the R package named "*fmetar*",[25] which pinpointed deviations in effect sizes within our meta-analysis model. We then conducted comparative analyses that included and excluded these outliers to evaluate the robustness of our findings. For effect sizes transformation, we also conducted comparative analyses that included and excluded studies with transformed effect sizes to ensure that our conclusions remained robust against potential biases introduced by these transformations.

Results

Search Outcomes

The search identified 2 472 studies. After removing 661 duplicates, 1 811 records were screened based on titles and abstracts. This screening resulted in the removal of 1 665 studies that were considered irrelevant. A full-text screening was conducted on the remaining 140 studies, and 17 studies met the inclusion criteria (see Figure 2.1). 25% of the full-text articles were co-screened, the agreement rate was 68%, indicating moderate agreement; disagreements were discussed and resolved through discussion.

Figure 2.1
PRISMA flow chart



Study Characteristics

Table 2.1 shows the characteristics of the 17 studies included in this review. The studies were published between 1994 and 2022 across the United States (*k* = 9), and one study from each of the following countries, Australia, Brazil, China, Copenhagen, South Korea, Sri Lanka, Vietnam, United Kingdom (*k* = 8). These studies comprised a total of 48 398 individuals, with ages ranging from 3 to 22 years. The mean age for different maltreatment types was 14.7 years for combined physical abuse, 13.7 years for physical abuse, 15.9 years for sexual abuse, 12.6 years for emotional abuse, 12.1 years for combined neglect. Among these, approximately 27 681 individuals (57.19%) were female. Participants came from a diverse range of ethnic backgrounds. A total of 7 studies reported effect sizes for combined maltreatment, 10 for physical abuse, 8 for sexual abuse, 6 for emotional abuse, 10 for combined neglect, and 3 for witnessing domestic abuse. Most of the studies were cross-sectional (*k* = 10) and the rest were longitudinal (*k* = 7). Most studies measured childhood maltreatment using questionnaires (*k* = 11) while others used records (*k* = 4) or interviews (*k* = 2).

Table 2.1

Characteristics of Studies Included in the Meta-Analyses

Article	Country	Study design	Sample size (mean age, gender, ethnicity)	Maltreatment type	Maltreatment measure	Measure type	Obesity measure	Covariates (adjusted for in ES)
Bennett et al. (2010)[38]	US	Longitudinal	185 (5.3 years, 55.7% female)	Neglect	Records (child protection service records)	Record	Measured	Age, sex, family public assistance
Duncan et al. (2015)[39]	US	Longitudinal	3699 (22 years, 100% female, 85.4% European or others)	Combined, physical, sexual, neglect	Self-report (telephone-adapted assessment)	Interview	Self-report	–
Fuemmeler et al. (2009)[40]	US	Cross-sectional	12,772 (22 years, 50.6% female, 63.3% White)	Physical, sexual, neglect	Self-report (questionnaire)	Questionnaire	Measured	Age, sex, ethnicity, parental education, depressive symptoms
Gooding et al. (2015)[41]	US	Cross-sectional	147 (14.9 years, 58% female, 43% White)	Combined, physical, sexual, emotional, witnessed domestic abuse	Self-report (Childhood Trauma Questionnaire; CTQ)	Questionnaire	Self-report	Race/ethnicity, parental education, smoking status, fast food consumption, sugar-sweetened beverage consumption, physical activity, internalising behaviour (including anxiety and depression)
Kennedy et al. (2020)[42]	US	Cross-sectional	447 (11 years, 46.5% female, 39.1% Latino, 37.8% Black)	Combined	Records (Department of Children and Family Services)	Record	Measured	–
Knutson et al. (2010)[43]	US	Cross-sectional	571 (6.25 years, 49.4% female, 61.6% White)	Neglect (physical, emotional)	Maternal report (Home Observation for Measurement of the Environment; HOME,	Interview	Measured	–

					and Reinforcement Survey Schedule; RRS)			
Lissau & Sørensen (1994)[44]	Copenhagen	Longitudinal	756 (21 years)	Neglect (physical, emotional)	Records (teachers' and nurses' reports)	Record	Measured	Age, sex, BMI in childhood
Mamun et al. (2007)[45]	Australia	Longitudinal	2578 (21 years, 50.6% female)	Sexual	Self-reported (questionnaire)	Questionnaire	Measured	Age, sex, maternal education, family income
Marques et al. (2022)[46]	Brazil	Cross-sectional	11,850 (15.5 years, 52.2% female, 47.8% Brown/ Mixed, 35.3% White	Physical, sexual	Self-report (questionnaire)	Questionnaire	Measured	Demographic, socioeconomic, and family context variables
Park & Kim (2018)[47]	South Korea	Longitudinal	1796 (9 years, 48.4% female)	Physical, neglect	Self-report (questionnaire)	Questionnaire	Self-report	Child gender, mother's age, family structure, mother's employment, family income, child health status, mother's health status, child's physical activity, hours of TV watched per week
Perera et al. (2009)[48]	Sri Lanka	Cross-sectional	2389 (18 years, 54% female)	Physical, emotional	Self-report (questionnaire)	Questionnaire	Measured	Sex
Schiff et al. (2021)[49]	US	Longitudinal	3170 (7 years, 48.8% female)	Combined, physical, sexual, emotional, neglect, witnessed domestic abuse	Caregiver report (Conflict Tactics Scale; CTS)	Questionnaire	Caregiver report	Household size, poverty level, individual-level time-invariant characteristics
Schneiderman et al. (2012)[8]	US	Cross-sectional	454 (10.8 years, 47% female, 77% Black/ Hispanic)	Combined, physical, sexual, neglect	Records (child welfare case reports)	Record	Measured	Age, gender, pubertal stage, depressive symptoms, neighbourhood characteristics
Soares et al. (2021)[26]	UK	Longitudinal	3223 (18 years, 100% female, 96% White)	Combined, emotional	Self-report (Child Abuse Questionnaire and the Sexual Experiences Survey)	Questionnaire	Measured	Age, sex, ethnicity, maternal education, paternal education, parental social class, and other types of abuse

Tran et al. (2017)[50]	Vietnam	Cross-sectional	1851 (14.2 years, 52.7% female)	Combined, physical, sexual, emotional, neglect, witnessed domestic abuse	Self-report (questionnaire)	Questionnaire	Self-report	Age, gender, household SES, rurality
Whitaker et al. (2007)[51]	US	Cross-sectional	2412 (3.2 years, 48.2% female, 52.2% Black/Hispanic)	Physical, emotional, neglect	Maternal report (Childhood Trauma Index; CTI)	Questionnaire	Measured	Age, sex, birth weight, maternal ethnicity, maternal education, maternal BMI, smoking during pregnancy
Zhang et al. (2021)[52]	China	Cross-sectional	98 (19.1 years, 71.4% female)	Combined	Self-report (Childhood Trauma Questionnaire – Short Form; CTQ-SF)	Questionnaire	Self-report	–

Quality Assessment

All 17 studies were evaluated using our quality assessment framework, with higher scores indicating higher study quality. The maximum score was 4; one study received a score of 1, 11 studies scored 2, two studies received a score of 3, and three studies achieved the maximum score of 4. Inter-rater reliability, as measured by the intraclass correlation coefficient, was 0.54, indicating moderate agreement. Discrepancies in ratings were resolved through discussion, and the final ratings for each study are presented in Table S2.

Meta-Analyses

Meta-analysis results examining the associations between childhood maltreatment and obesity are reported in Table 2.2. These include findings from three analysis phases: the original analysis (Phase A), and two sets of sensitivity analyses, one managing outliers (Phase B) and one excluding studies with transformed effect sizes (Phase C). Phase A was designated as the primary analysis. Due to an insufficient number of studies for the subtype witnessing domestic abuse (k = 3), which falls below the commonly accepted threshold of five studies for meta-analysis[17], this category was excluded. Additionally, the study by Soares et al.[26] was identified as a frequent outlier, potentially due to its unique sample criteria that included individuals with pre-defined abuse exposure and cardiometabolic conditions, differing from other included studies. Forest plots for each maltreatment subtype are provided in the supplementary material (Figure S1– S5).

Table 2.2

Meta-Analysis Results for Childhood Maltreatment and Obesity Outcomes

Maltreatment Type	Analysis Phase	k (No. of studies)	Total no. of participants	Pooled OR (95% CI)	I^2	95% PI	Studies excluded from analysis
Combined Abuse	A	7	11,238	1.31 (0.72, 2.38)	98.4%	0.17, 10.33	
	B	6	8,015	0.96 (0.68, 1.34)	93.6%	0.32, 2.82	Soares et al. (2021)
	C	5	7,917	1.02 (0.53, 1.98)	94.6%	0.21, 4.88	Soares et al. (2021); Zhang et al. (2021)
Physical Abuse	A	10	40,018	1.08 (0.96, 1.21)	40.3%	0.79, 1.46	
	B	9	39,564	1.05 (0.96, 1.15)	8.4%	0.91, 1.21	Schneiderman et al. (2012)
	C	9	38,744	1.07 (0.90, 1.27)	40.2%	0.63, 1.80	Park & Kim (2018)
Sexual Abuse	A	8	37,825	**1.31 (1.01, 1.70)**	72.7%	0.58, 3.00	
	B	7	34,655	**1.37 (1.07, 1.75)**	71.2%	0.63, 2.96	Schiff et al. (2021)
	C	-	-	-	-	-	-
Emotional Abuse	A	6	13,192	1.84 (0.88, 3.82)	94.5%	0.17, 20.06	
	B, C	5	9,969	1.01 (0.80, 1.28)	34.5%	0.59, 1.72	Soares et al. (2021)
Combined Neglect	A	10	27,144	1.24 (0.96, 1.60)	72.3%	0.56, 2.75	
	B	8	25, 934	**1.21 (1.03, 1.42)**	30.8%	0.85, 1.71	Lissau & Sorensen (1994); Schneiderman et al. (2012)
	C	8	25,299	1.32 (0.71, 2.43)	77.5%	0.21, 8.34	Park & Kim (2018); Knutson et al. (2010).

Note. Analysis Phase A = initial analysis phase; B = after removing outliers; C = after excluding converted effect sizes. Analyses reported in **bold** are statistically significant ($p < .05$).

A series of random-effects meta-analyses were conducted to examine the associations between childhood maltreatment subtypes and increased risk of obesity. Among the five maltreatment types, sexual abuse showed a significant association (OR = 1.31, 95% CI [1.01, 1.70]); 95% PI [0.58, 3.00], which remained significant after removing a statistical outlier (OR = 1.37, 95% CI [1.07, 1.75]); 95% PI [0.63, 2.96]. Combined neglect was statistically not significant in the primary analysis, but the association became significant after removing the statistical outliers (OR = 1.21, 95% CI [1.03, 1.42]), 95% PI [0.85, 1.71]. All other pooled estimates were non-

significant, with odds ratios ranging from 0.96 to 1.84. Heterogeneity varied widely across models, with I^2 values ranging from low (8.4%) to substantial (98.4%). Prediction intervals were generally wide, indicating variation in true effect sizes across populations and study designs.

Moderator and Subgroup Analysis

The results of the moderator and subgroup analyses are summarized in Table 2.3 and 2.4. Substantial heterogeneity was observed in all the moderator and subgroup analyses with I^2 ranging between 43.2% to 97%, apart from physical abuse (I^2 = 11.6% to 14.3%).

Moderation analyses assessed the effects of continuous variables, including participants age, study publication year, and study quality rating. Overall, no significant moderators were identified across various types of childhood maltreatment, except for publication year in the case of combined neglect (β = -0.05, SE = 0.02, p = 0.01).

Table 2.3

Moderation Analyses (Continuous Data)

Maltreatment Type	Moderator	*β*	95% CI	*SE*	*p*-value	QE	I^2 (95% CI)
Combined Abuse	Age	0.08	-0.04, 0.20	0.06	0.21	311.34***	94.8% (92.9%, 99.4%)
	Publication Year	-0.02	-0.30, 0.26	0.14	0.89	324.30***	96.6% (93.7%, 99.6%)
	Quality Rating	0.09	-0.98, 1.16	0.55	0.86	356.81***	97% (93.7%, 99.6%)
Physical Abuse	Age	-0.00	-0.02, 0.02	0.01	0.74	18.10	14.3% (0%, 62%)
	Publication Year	0.01	-0.02, 0.03	0.01	0.56	18.13	14.2% (0%, 60.4%)
	Quality Rating	0.05	-0.10, 0.19	0.07	0.52	16.24	11.6% (0%, 62.1%)
Sexual Abuse	Age	0.02	-0.04, 0.09	0.03	0.47	31.85**	43.2% (18.7%, 87.6%)
	Publication Year	0.00	-0.05, 0.05	0.02	0.99	36.52***	45.8% (20.7%, 89.9%)
	Quality Rating	-0.10	-0.39, 0.18	0.15	0.47	34.34***	46.4% (19.3%, 88.2%)
Emotional Abuse	Age	0.11	-0.04, 0.26	0.08	0.16	70.71***	88.7% (50.3%, 96.6%)
	Publication Year	0.05	-0.11, 0.21	0.08	0.53	75.42***	88.9% (65.5%, 98.3&)
	Quality Rating	-0.50	-1.52, 0.52	0.52	0.33	76.07***	90.9% (60.8%, 97.7%)
Neglect	Age	-0.00	-0.04, 0.04	0.02	0.98	34.29***	55.8% (54.7%, 95.3%)
	Publication Year	-0.05	-0.09, -0.01	0.02	0.01*	27.95*	49% (30.7%, 91.6%)
	Quality Rating	0.04	-0.26, 0.34	0.15	0.77	35.95***	59.3% (54.5%, 95.3%)

Note. $p < .05$ (*), $p < .001$ (**), $p < .0001$ (***).

For subgroup analyses, only studies measuring sexual abuse and combined neglect met the requirements for further analysis, as there were sufficient included studies and observations within each subgroup (i.e. cross-sectional versus longitudinal.[21, 22] Subgroup results revealed no significant differences in pooled effect sizes between study designs ($p = .87$ for sexual abuse, $p = .20$ for combined neglect).

Table 2.4
Subgroup Analysis (Categorical Data)

Maltreatment Type	Moderator	k	N	Pooled effect size (OR)	95% CI	Q	I^2 (95% CI)	Moderation effect
Sexual Abuse	Study Design							p = .87
	Cross-sectional	7	27,074	1.26	0.96, 1.64	16.17*	38.3% (4.3%, 85.5%)	
	Longitudinal	4	10,751	1.32	0.75, 2.33	13.41	47.8% (14.7%, 98.7%)	
Combined Neglect	Study Design							p = .20
	Cross-sectional	6	18,060	1.00	0.58, 1.73	13.77*	50.9% (6.8%, 94%)	
	Longitudinal	5	9,084	2.10	0.39, 11.28	17.55**	70.4% (50.3%, 98.3%)	

Note. $p < .05$ (*), $p < .001$ (**), $p < .0001$ (***).

Discussion

This review identified and synthesised current findings of the association between childhood maltreatment and obesity in young people. Non-significant associations were found for most maltreatment types, except for sexual abuse. Meta-analytic findings suggested a significant association between sexual abuse and increased risk of obesity in young people (OR = 1.31, 95% CI [1.01, 1.70]), which remained significant after removing the outlier (OR = 1.37, 95% CI [1.07, 1.75]). Sensitivity analysis also revealed a significant association between combined neglect and obesity after removing outliers (OR = 1.21, 95% CI [1.03, 1.42]). These results underscore the complex nature of the relationship between childhood maltreatment and obesity.

The significant association for sexual abuse contrasts with Danese and Tan[3] findings but aligns with Schroeder et al.[5], suggesting that sexual abuse may exert a unique influence on obesity risk in young people during adolescence. In line with this idea, research has shown that

sexual abuse is associated with distinct BMI trajectories, with initially lower BMI in childhood followed by an increase from mid-adolescence into early adulthood.[8, 27] According to the Self-Objectification Theory,[28] individuals who have experienced sexual abuse may come to view their bodies from an objectified perspective to be evaluated based on appearance. Sexual abuse, as a form of physical violation, can disrupt an individual's sense of bodily ownership and safety, contributing to chronic body-shame, emotional disconnection, and heightened body surveillance. These effects can be amplified during adolescence and early adulthood, a critical period for self-identity and body image development. Such internalised negative evaluation may alter individuals' cognitive appraisal of their body (e.g. "my body does not deserve care") and emotional states (e.g. shame and guilt), potentially leading to maladaptive coping mechanisms such as emotional eating[29] to regulate distress and manage feelings of disembodiment.

Another explanation is that sexual abuse may increase obesity risk via dysregulation of the hypothalamic-pituitary-adrenal (HPA) axis. This mechanism can be understood through Allostatic Load Theory[30] which proposes that repeated or chronic stress produces a cumulative toll on the body, including HPA dysregulation and metabolic changes that elevate obesity risk. Sexual abuse has been linked to heightened cortisol reactivity, meaning the body releases more cortisol than usual when stressed, which has been associated with accelerated BMI growth in adolescent girls.[31] Over time, chronic stress may lead to HPA axis attenuation, a "burnout" effect in which cortisol levels fall below normal.[32] This long-term dysregulation contributes to physiological alteration that increases the risk of obesity from late adolescence into adulthood. However, HPA alterations are reported across multiple maltreatment types and are most

consistently characterised by blunted cortisol stress reactivity rather than a uniform cortisol increase, indicating that this pathway is not specific to sexual abuse but reflects a broader maltreatment-related predisposition. [33, 34]

Multiple sensitivity analyses were conducted to test the robustness of our findings. While this approach strengthens transparency, the resulting multiplicity is a limitation because it increases the likelihood of chance findings. Since no adjustments for multiple comparisons were applied, these analyses should be considered exploratory.

In the primary analysis, combined neglect was not significantly associated with obesity. A statistically significant association emerged only after excluding outliers in one sensitivity analysis. While neglect can be linked to self-regulatory difficulties in theory [35], which may increase vulnerability to dysregulated eating, the present data do not provide direct evidence for this pathway. Given that statistical significance was observed in only one of several analyses and no multiplicity adjustment was applied, this result should be treated as exploratory and interpreted with caution. Future longitudinal mediation studies are needed to test whether neglect predicts dysregulated eating via impaired self-regulation.

Moderator and subgroup analyses suggested that the association between childhood maltreatment and obesity was mostly not influenced by the study characteristics examined, including publication year, age, study quality, and study design. The only exception was combined neglect, which indicated that more recent studies showed weaker associations between combined neglect and obesity. However, given the small number of studies included

for each type of maltreatment, we were unable to assess publication bias and most of the moderators and subgroup analyses. These results should be interpreted with caution.

Notably, we did not conduct gender subgroup analyses. Only a limited number of included studies reported gender-stratified, comparably adjusted effect sizes, and the small number of studies within each maltreatment subtype meant that further stratification by gender would have produced underpowered and unstable estimates. Given our primary aim was to synthesise odds ratios by maltreatment subtype, we excluded gender as a moderator. Future research with consistent gender-stratified reporting is needed to clarify potential differences.

Several factors warrant caution when interpreting our findings. The agreement rate during study selection screening was 68% and the intraclass correlation coefficient during quality rating was 0.54; both were relatively low and represent a key limitation of this study. Low screening agreement likely reflects differences in how the screening criteria were interpreted. Since agreement percentage does not adjust for chance and fell below commonly used calibration targets, selection bias is possible and may have influenced the pooled estimates and contributed to between-study heterogeneity. The intraclass correlation coefficient was also low, potentially due to our use of an adapted assessment tool; future studies could employ a single established tool, such as the Effective Public Health Practice Project (EPHPP) Quality Assessment Tool [36].

In addition, excluding Adverse Childhood Experiences (ACE)-only studies (e.g. parental substance use, household dysfunction) may have removed neglect-like exposures, potentially biasing our sample and underestimating the association between neglect and obesity.

Finally, we excluded intervention trials and treatment seeking clinical samples (e.g. eating disorders, post-traumatic stress disorders) to focus on naturalistic associations between maltreatment and obesity in the general population. This decision may bias the estimates toward community and non-clinical populations and underestimate the strength of associations that may emerge in service-engaged groups, who often present with greater complexity and poorer clinical outcomes. As health systems increasingly develop specialist and trauma-informed services, future research could integrate evidence from intervention and clinical contexts to clarify how treatment setting may shape the association between maltreatment and obesity. Nevertheless, the findings hold value in capturing the dynamics at play before the development of clinical conditions.

Implications for Future Research Studies

Given that the mean age of participants with a history of sexual abuse in our included studies was 16 years, our findings may partly reflect a sensitive developmental window in mid-to-late adolescence when obesity-related consequences of sexual abuse begin to manifest. Future research should examine how developmental timing interacts with different maltreatment subtypes to influence obesity risk, particularly within a biopsychosocial framework.

Only three studies in our review accounted for the role of depression. Since depression is considered both a common consequence of childhood maltreatment and a risk factor for obesity, controlling for depression in data analyses helps to isolate the specific contribution of childhood maltreatment to obesity outcomes. This helps to clarify whether maltreatment affects obesity directly or indirectly, and whether any observed association between maltreatment and obesity might be explained by depression and not the maltreatment itself. Future research should consider controlling for depression in their studies.

While there is a degree of standardisation in measuring childhood maltreatment and obesity, the choice between focusing on traditional maltreatment types or broader ACEs remains a matter of concern. There is ongoing debate about the best metrics for assessing childhood maltreatment and obesity in children and adolescents, for example, waist-to-height has been suggested as a potentially better indicator of central obesity and chronic health risk.[36] Future studies should consider these alternative metrics to improve the accuracy of obesity assessments in young populations.

Clinical Implications

The observed associations have important clinical implications during the transition from adolescence to young adulthood, particularly in highlighting the potential value of early identification and trauma-informed intervention within obesity prevention and care in the general population. Screening for early experiences of childhood maltreatment during adolescence may offer a critical window for developmentally responsive intervention. This aligns with previous research emphasising the importance of early identification of

maltreatment in community-based obesity prevention efforts during adolescence.[8, 27] In addition, integrating trauma-informed care that addresses both physiological and psychological processes, such as stress regulation, emotional coping, and self-perception, could potentially strengthen obesity-related prevention and treatment strategies. Continued research is needed to understand the mechanisms linking early childhood maltreatment and obesity risk and to inform evidence-based clinical practices.

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Author Contributions

Alyse Y. Hung: Conceptualisation; Methodology; Research Design; Project Administration; Literature Review; Data Curation; Formal Analysis; Interpretation; Writing – Original Draft; Writing – Review & Editing.

Richard Meiser-Stedman: Conceptualisation; Methodology; Research Design; Supervision; Writing – Review & Editing.

Saber Sami: Conceptualisation; Research Design; Supervision; Writing – Review & Editing.

Henry Chiu: Data Curation; Writing – Review & Editing.

Kenny K. Chiu: Conceptualisation; Methodology; Research Design; Supervision; Writing - Original Draft; Writing – Review & Editing.

Competing Interests

The authors declare no competing interests.

Data Availability Statement

This study is a systemic review and meta-analysis based on previously published studies. All data generated or analysed during this study are included in the published articles and supplementary materials.

References

1. NHS Digital. *Health Survey for England 2022: Part 2* [Internet]. Leeds: NHS Digital; 2023 [cited 2025 Jul 1]. Available from: https://digital.nhs.uk/data-and-information/publications/statistical/health-survey-for-england/2022-part-2
2. Radford L. *Child abuse and neglect in the UK today*. London: NSPCC; 2011.
3. Danese A, Tan M. Childhood maltreatment and obesity: systematic review and meta-analysis. *Mol Psychiatry*. 2014;19(5):544–54.
4. Elsenburg LK, van der Ende J, Verhulst FC. The relationship between adverse life events and body mass index in children and adolescents: A systematic review. *J Pediatr Psychol*. 2017;42(5): 555–66.
5. Schroeder RJ, Johnson KC, Wieckowski AT. Adverse childhood experiences and obesity in children: a systematic review. *Child Abuse Negl*. 2021;120:105325.
6. World Health Organization. *Child maltreatment* [Internet]. Geneva: WHO; 2024 [cited 2025 Jul 1]. Available from: https://www.who.int/news-room/fact-sheets/detail/child-maltreatment
7. Hawton K, Saunders KE, O'Connor RC. Self-harm and suicide in adolescents. *Lancet*. 2012;379(9834):2373–82.
8. Schneiderman JU, Mennen FE, Negriff S, Trickett PK. Overweight and obesity among maltreated youth placed in foster care. *Child Abuse Negl*. 2015;43:48–58.
9. Noll JG. Sexual abuse and obesity in adolescence: a systematic review. *J Adolesc Health*. 2017;60(3):273–83.

10. Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *BMJ*. 2009;339:b2535.
11. Peterson RA, Brown SP. On the use of beta coefficients in meta-analysis. *J Appl Psychol*. 2005;90(1):175–81.
12. National Institute for Clinical Excellence. *Quality appraisal checklist for studies reporting correlations and associations*. London: NICE; 2012.
13. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. *PLoS Med*. 2007;4(10):e296.
14. Balduzzi S, Rücker G, Schwarzer G. *meta: An R package for meta-analysis*. R package version 4.9-7; 2019.
15. R Core Team. *R: a language and environment for statistical computing*. Vienna: R Foundation for Statistical Computing; 2024.
16. Bevan E, Higgins DJ. Is domestic violence learned? The contribution of five forms of child maltreatment to men's violence and adjustment. *J Fam Viol*. 2002;17:223–45.
17. Jackson DB, Turner RJ. The relationship between childhood maltreatment and obesity in adulthood: a systematic review. *J Interpers Violence*. 2017;32(19):2943–66.
18. Higgins JP, Thompson SG. Quantifying heterogeneity in a meta-analysis. *Stat Med*. 2002;21(11):1539–58.
19. Higgins JP, Thompson SG, Deeks JJ, Altman DG. Measuring inconsistency in meta-analyses. *BMJ*. 2003;327(7414):557–60.

20. IntHout J, Ioannidis JPA, Rovers MM, Goeman JJ. Plea for routinely presenting prediction intervals in meta-analysis. *BMJ Open*. 2016;6(7):e010247.
21. Fu R, Gartlehner G, Grant M, Shamliyan T, Sedrakyan A, Wilt TJ, et al. Conducting quantitative synthesis when comparing medical interventions: AHRQ and the Effective Health Care Program. *J Clin Epidemiol*. 2011;64(11):1187–97.
22. Schwarzer G, Carpenter JR, Rücker G. *Meta-analysis with R*. Cham: Springer; 2015.
23. Egger M, Smith GD, Schneider M, Minder C. Bias in meta-analysis detected by a simple, graphical test. *BMJ*. 1997;315(7109):629–34.
24. Sterne JAC, Egger M. Funnel plots for detecting bias in meta-analysis: guidelines on choice of axis. *J Clin Epidemiol*. 2001;54(10):1046–55.
25. Harrer M, Cuijpers P, Furukawa T, Ebert D. *Doing meta-analysis with R: a hands-on guide*. Boca Raton: Chapman and Hall/CRC; 2021.
26. Soares AG, Zimmerman A, Zammit S, Karl A, Halligan SL, Fraser A. Abuse in childhood and cardiometabolic health in early adulthood: evidence from the Avon Longitudinal Study of Parents and Children. *J Am Heart Assoc*. 2021;10(24):e021701.
27. Sokol RL, Ennett ST, Shanahan ME, Gottfredson NC, Poti JM, Halpern CT, et al. Maltreatment experience in childhood and average excess body mass from adolescence to young adulthood. *Child Abuse Negl*. 2019;96:104070.
28. Fredrickson BL, Roberts TA. Objectification theory: toward understanding women's lived experiences and mental health risks. *Psycholo Women Q*. 1997;21(2):173-206.
29. Noll JG, Zeller MH, Trickett PK, Putnam FW. Obesity risk for female victims of childhood sexual abuse: a prospective study. *Pediatrics*. 2007;120(1):e61–7.

30. McEwen BS, Stellar E. Stress and the individual: mechanisms leading to disease. *Arch Intern Med*. 1993;153(18):2093–101.

31. Peckins MK, Negriff S, Gordis EB, Zhen A, Susman EJ. Maltreatment type differences in cortisol stress response trajectories across adolescence. *Child Dev*. 2024;95(4):1092–108.

32. Li JC, Hall MA, Shalev I, Schreier HM, Zarzar TG, Marcovici I, et al. Hypothalamic-pituitary-adrenal axis attenuation and obesity risk in sexually abused females. *Psychoneuroendocrinology*. 2021;129:105254.

33. Schaer S, Muerner-Lavanchy I, Schmidt SJ, Koenig J, Kaess M. Child maltreatment and hypothalamic-pituitary-adrenal axis functioning: A systematic review and meta-analysis. Frontiers in neuroendocrinology. 2022 Jul 1;66:100987.

34. Leroux PA, Dissaux N, Le Reste JY, Bronsard G, Lavenne-Collot N. Association between HPA axis functioning and mental health in maltreated children and adolescents: a systematic literature review. Children. 2023 Aug 3;10(8):1344.

35. Baumeister RF, Newman LS. Self-regulation of cognitive inference and decision processes. *Pers Soc Psychol Bull.* 1994;20(1):3-19.

36. Thomas BH, Ciliska D, Dobbins M, Micucci S. Effective Public Health Practice Project (EPHPP) quality assessment tool for quantitative studies. Effective Public Health Practice Project. 1998

37. Tewari A, Kumar G, Maheshwari A, Tewari V, Tewari J. Comparative evaluation of waist-to-height ratio and BMI in predicting adverse cardiovascular outcome in people with diabetes: a systematic review. *Cureus*. 2023;15(5):e38513.

38. Bennett DS, Wolan Sullivan M, Thompson SM, Lewis M. Early child neglect: does it predict obesity or underweight in later childhood? *Child Maltreat*. 2010;15(3):250–4.
39. Duncan AE, Sartor CE, Jonson-Reid M, Munn-Chernoff MA, Eschenbacher MA, Diemer EW, et al. Associations between body mass index, post-traumatic stress disorder, and child maltreatment in young women. *Child* A*buse* N*egl.* 2015;45:154–62.
40. Fuemmeler BF, Dedert E, McClernon FJ, Beckham JC. Adverse childhood events are associated with obesity and disordered eating: results from a US population-based survey of young adults. *J Trauma Stress*. 2009;22(4):329–33.
41. Gooding HC, Milliren C, Austin SB, Sheridan MA, McLaughlin KA. Exposure to violence in childhood is associated with higher body mass index in adolescence. *Child Abuse Negl*. 2015;50:151–8.
42. Kennedy AK, Schneiderman JU, Negriff S. Body appreciation and body dissatisfaction between maltreated and comparison adolescents. *Child Youth Serv Rev*. 2020;108:104514.
43. Knutson JF, Taber SM, Murray AJ, Valles NL, Koeppl G. The role of care neglect and supervisory neglect in childhood obesity in a disadvantaged sample. *J Pediatr Psychol*. 2010;35(5):523–32.
44. Lissau I, Sørensen TIA. Seasonal variation in weight and overweight in a nationally representative sample of Danish young men. *Int J Obes Relat Metab Disord*. 1994;18(11):727–31.

45. Mamun AA, Lawlor DA, O'Callaghan MJ, Bor W, Williams GM, Najman JM. Does childhood sexual abuse predict young adult's BMI? A birth cohort study. *Obesity (Silver Spring)*. 2007;15(8):2103–10.

46. Marques ES, Hasselmann MH, de Barros Vianna GV, de Paula Mendonça E, Azeredo CM. Association between interpersonal violence with inadequate nutritional status among Brazilian adolescents. *J Interpers Violence*. 2022;37(13–14):NP12066–85.

47. Park A, Kim Y. The longitudinal influence of child maltreatment on child obesity in South Korea: the mediating effects of low self-esteem and depressive symptoms. *Child Youth Serv Rev*. 2018;87:34–40.

48. Perera B, Østbye T, Ariyananda PL, Lelwala E. Prevalence and correlates of physical and emotional abuse among late adolescents. *Ceylon Med J*. 2009;54(1).

49. Schiff M, Helton J, Fu J. Adverse childhood experiences and obesity over time. *Public Health Nutr*. 2021;24(11):3205–9.

50. Tran NK, Van Berkel SR, van IJzendoorn MH, Alink LR. The association between child maltreatment and emotional, cognitive, and physical health functioning in Vietnam. *BMC Public Health*. 2017;17:1–13.

51. Whitaker RC, Phillips SM, Orzol SM. The association between maltreatment and obesity among preschool children. *Pediatrics*. 2007;120(3):540–6.

52. Zhang H, Luo Y, Davis T, Zhang L. Interactive effects of childhood maltreatment and tonic respiratory sinus arrhythmia on young adults' depressive symptoms. *Psychophysiology*. 2021;58(10):e13900.

Supplementary Materials

Table S.1

Quality Assessment Framework

1.	Was the study population clearly specified and defined?	Yes (1) = Clear description of ≥ 3 of the following: location, gender, age and ethnicity No (0) = Clear description of < 3 of the following: location, gender, age and ethnicity
2.	Was sampling carried out appropriate to the study design, such that the likelihood of sampling bias was minimised as far as possible?	Yes (1) = probability sampling, e.g. random sampling, whole community method No (0) = non-probability sampling, e.g. convenience sampling, self-referral to study
3.	Was the likelihood of non-response bias minimised as far as possible?	Yes (1) = response rate at least 70% OR an analysis performed that showed no significant difference in relevant demographic characteristics between responders and non-responders No (0) = response rate less than 70% and no analysis performed that showed no significant difference in relevant demographic characteristics between responders and non-responders; did not document response rates
4.	Was the childhood maltreatment measure used reliable?	Yes (1) = Measure with internal consistency (Cronbach's alpha) ≥ 0.7 as reported in the paper; OR measure that is validated in other peer reviewed papers (e.g. CTQ) as having adequate internal consistency; OR clinical or medical records

		No (0) = Measure with internal consistency (Cronbach's alpha) < 0.7 as reported in the paper; AND measure that is not validated in other peer reviewed papers as having adequate internal consistency; AND clinical and medical record without details of how maltreatment was measured AND self-report maltreatment status

Table S.2
Quality Assessment Ratings

Article	Study population	Sampling	Non-response bias	Measure	Total (0-4)
Bennett et al., 2010	+	-	-	+	2
Duncan et al., 2015	+	+	-	+	3
Fuemmeler et al., 2009	+	+	-	-	2
Gooding et al., 2015	+	-	-	+	2
Kennedy et al., 2020	+	-	-	+	2
Knutson et al., 2010	+	-	-	+	2
Lorber et al., 2017	+	-	+	+	3
Mamun et al., 2007	+	-	-	-	1
Marques et al., 2022	+	+	+	-	3
Park & Kim, 2018	+	+	+	+	4
Perera et al., 2009	+	+	-	-	2
Schiff et al., 2021	+	+	+	+	4
Schneiderman et al., 2012	+	-	-	+	2
Soares et al., 2021	+	-	-	+	2
Tran et al., 2017	+	+	+	+	4
Whitaker et al., 2007	+	-	-	+	2
Zhang et al., 2021	+	-	-	+	2

Notes: + = high quality; - = low quality.

Figure S.1

Forest Plot for Combined Abuse

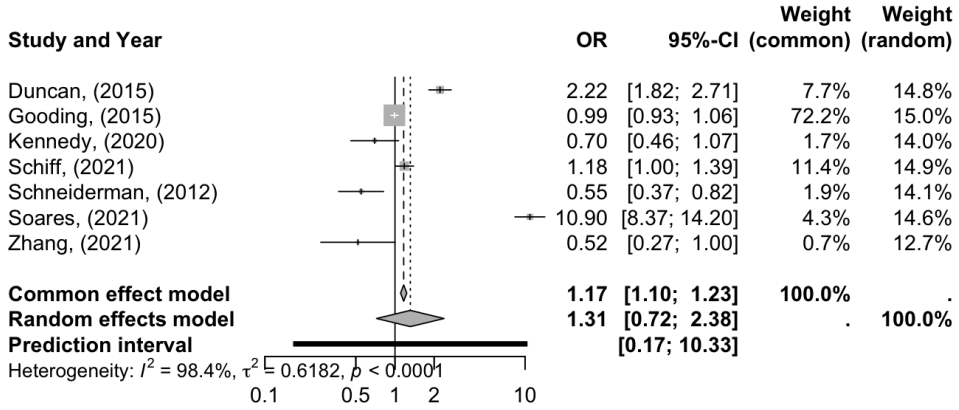


Figure S.2

Forest Plot for Physical Abuse

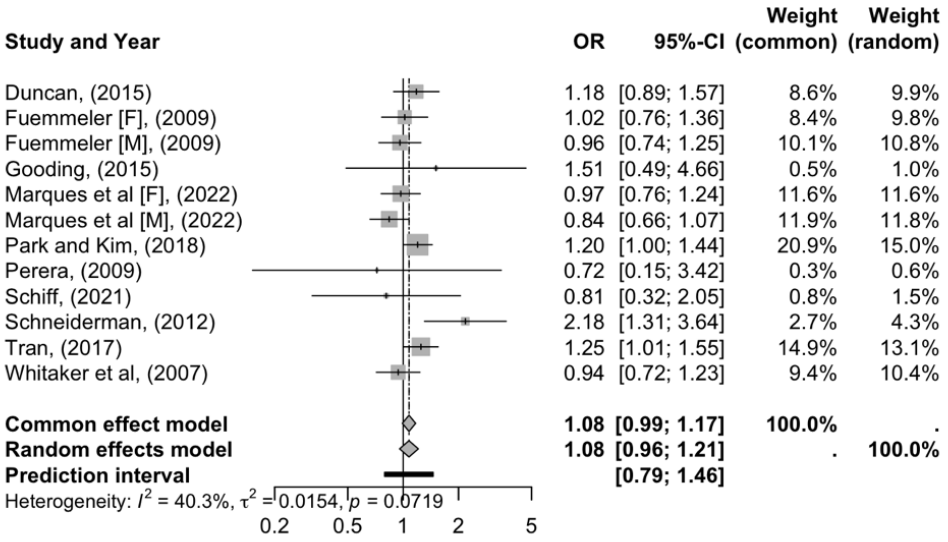


Figure S.3

Forest Plot for Sexual Abuse

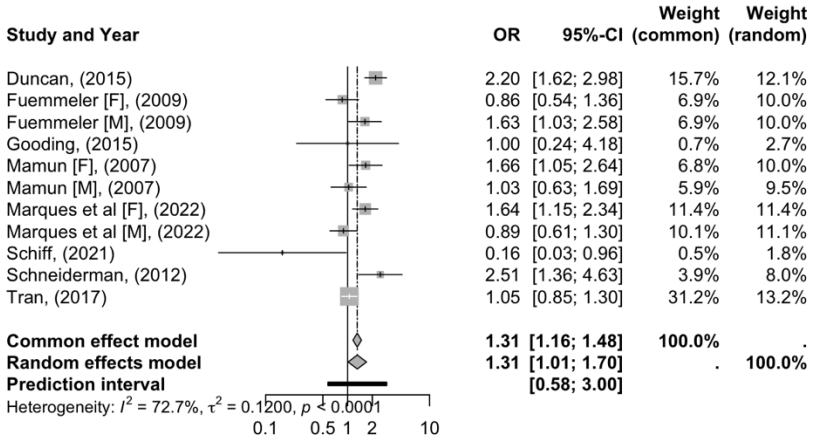


Figure S.4

Forest Plot for Emotional Abuse

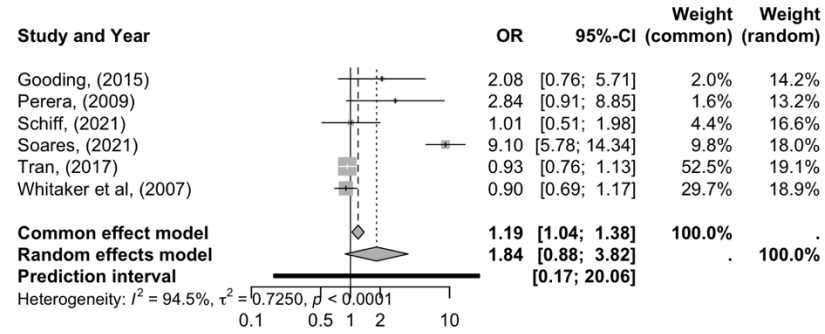
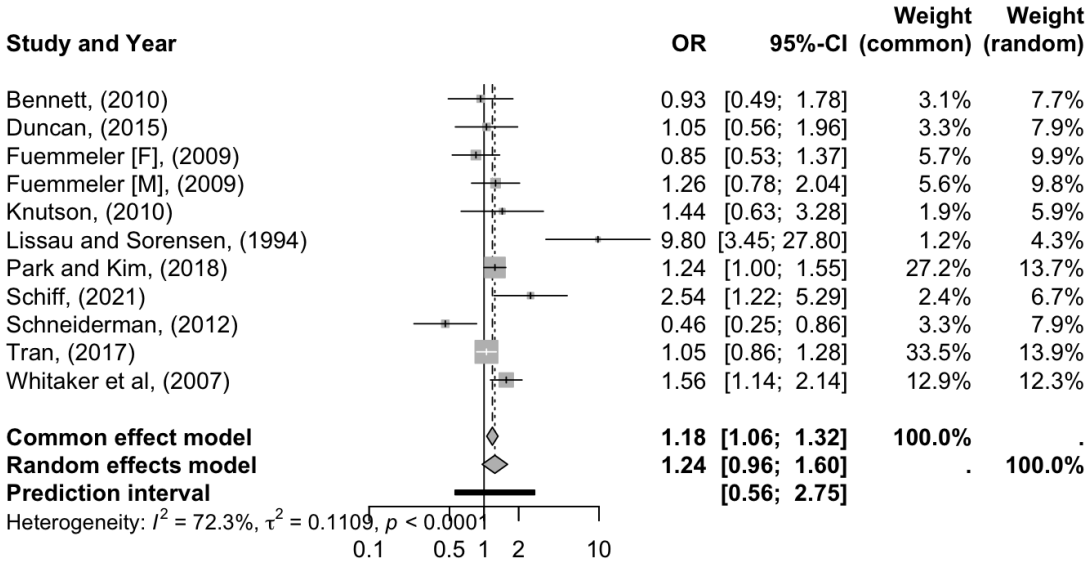


Figure S.5

Forest Plot for Combined Neglect



Chapter Three: Bridging Chapter

The systematic review and meta-analysis examined existing evidence on the association between childhood maltreatment and obesity in individuals up to the age of 25. Most of the included studies were conducted in United States (k = 9), with only one study based in the United Kingdom. That study focused on female participants aged 18 and examined the impact of combined maltreatment and emotional abuse on obesity risk. While it accounted for environmental factors (e.g. social class) as a covariate, it did not control for other psychological (e.g. depression) or cognitive (e.g. executive function) factors. This highlights a key research gap for United Kingdom based evidence to better understand how childhood maltreatment relates to weight outcomes in this age group within a community context.

Another methodological consideration in the reviewed literature was the frequent use of categorical outcomes (e.g. overweight or obese). Although these categories facilitate clinical interpretation, they present several limitations, particularly in developmental and community-based research. Converting standardised Body Mass Index (zBMI; BMI-for-age-and-sex z-score) or Body Mass Index (BMI; kg/m^2) into broad weight categories reduces a continuous variable into arbitrary threshold, potentially over-simplifying weight status and lowering the sensitivity to detect early risk in community and young aged population where clinical obesity may be less prevalent. In contrast, continuous measures offer greater precision and allow for timely identification of gradual weight gain before reaching clinical cut-offs, which can be crucial for early intervention in the community. Therefore, adopting a continuous approach aligns more closely with the goal of identifying weight-related risk within community samples across this age range.

Chapter Four: Empirical Study

Examining the association between childhood maltreatment and Body Mass Index in young people: a cross-sectional study

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Abstract

This study investigated the relationship between childhood maltreatment and Body Mass Index (BMI; kg/m²) in a youth community sample in the United Kingdom. The sample consisted of 789 participants, analyses were conducted separately for the adolescent (N = 365, *M* = 15.9 years) and the young adult (N = 424, *M* = 21.0 years) group. Multiple linear regression analyses were conducted to examine whether childhood maltreatment is associated with BMI. Structural equation modelling analyses were conducted to examine whether the association was mediated by depressive symptoms and inhibitory control. In both age groups, a positive correlation was found between childhood maltreatment and BMI, and childhood maltreatment did not predict BMI when controlling for depressive symptoms. Contrary to our hypotheses, neither depressive symptoms nor inhibitory control mediated the relationship between childhood maltreatment and BMI. Longitudinal research is needed to examine the underlying mechanisms of the association, stratified by maltreatment subtype and gender in the future.

Introduction

Childhood maltreatment has profound and long-term implications for emotional, cognitive, and physical well-being across the lifespan (Gilbert et al., 2009). It has been consistently linked to increased risk for a range of mental health difficulties such as depression, anxiety, aggression (Brown et al., 2016; Lee & Hoaken, 2007), substance misuse and eating disorders (Fosse & Holen, 2006; Lo & Cheng, 2007), as well as physical health conditions such as obesity and cardiometabolic disease (Danese & Tan, 2014; Heim et al., 2009). Understanding how childhood maltreatment is associated with both mental and physical health outcomes and how these factors interact can help inform the development of effective clinical psychology prevention and intervention for individuals who have experienced childhood maltreatment.

While a substantial body of research has established an association between childhood maltreatment and obesity in adulthood, findings in children and adolescents have been mixed (Danese & Tan, 2014; Elsenburg et al., 2017; Schroeder et al., 2021). Meta-analyses suggest that the strength and presence of this association in children and adolescents may depend on a range of factors, including the type and severity of maltreatment, gender, and the developmental period in which outcomes are assessed (Elsenburg et al., 2017; Schroeder et al., 2021). One study proposed that the statistically significant association between childhood maltreatment and Body Mass Index (BMI) may not emerge until around age 18 (Sokol et al., 2019). The current understanding is hindered by the lack of studies focusing on both adolescents and young adults. Adolescence and young adulthood represent crucial transitional stages in development, during which the effect of early childhood maltreatment may emerge in distinct ways.

Psychological mechanisms underlying the link between childhood maltreatment and BMI remain underexplored. Identifying mediating factors could provide insight into how maltreatment influences weight outcomes and inform more targeted interventions. Among these, depressive symptoms and inhibitory control are two particularly relevant yet understudied factors.

A meta-analysis suggested a potential mediative role of depressive symptoms in the relationship between childhood maltreatment and obesity (Danese & Tan, 2014). While childhood maltreatment has been consistently linked to depression (Humphreys et al., 2021) and depression is found to have a bidirectional relationship with obesity (Luppino et al., 2010; Park et al., 2025), the extent to which depressive symptoms mediate the relationship between childhood maltreatment and BMI during adolescence and young adulthood has not been empirically examined.

Inhibitory control is a core component of executive functioning, reflecting the capacity to suppress impulsive responses and regulate behaviour (Diamond, 2013). A meta-analysis supported a positive association between childhood maltreatment and impulsivity (Liu et al., 2019). Moreover, a systematic review with studies utilising the Stop-Signal Paradigm demonstrated that the results of tasks predicted weight loss in adolescent and adult populations, supporting the role of inhibitory control in weight outcomes (Kulendran et al., 2017). This is further supported by a more recent literature review conducted by De Klerk and colleagues (2023), who found that low inhibitory control is predictive of weight gain, and high inhibitory control is predictive of weight loss. It is worth noting that two meta-analyses had identified a larger effect size of a Go/No-Go Paradigm in influencing eating behaviour than a

Stop-Signal Paradigm (Allom et al., 2016; Jones et al., 2016), suggesting Go/No-Go task could be one suitable behavioural measure when examining the mediating role of inhibitory control in the association between childhood maltreatment and BMI.

The current study examined the cross-sectional associations between childhood maltreatment, depressive symptoms, inhibitory control, and BMI in a large community sample in the United Kingdom, consisting of adolescents aged 14 to 17 and young adults aged 18 to 25. The aim was to investigate whether childhood maltreatment is positively associated with BMI, and whether depressive symptoms and inhibitory control mediate this relationship. The following hypotheses were proposed:

Hypothesis 1: Childhood maltreatment will be positively associated with standardised Body Mass Index (zBMI; BMI-for-age-and-sex z-score) in the adolescent sample.

Hypothesis 2: Childhood maltreatment will be positively associated with BMI in the young adult sample.

Hypothesis 3: The association between childhood maltreatment and zBMI/ BMI will be mediated by inhibitory control in both adolescents (Hypothesis 3a) and young adults (Hypothesis 3b).

Hypothesis 4: The association between childhood maltreatment and zBMI/ BMI will be mediated by depressive symptoms in both adolescents (Hypothesis 4a) and young adults (Hypothesis 4b).

Method

Participants and Procedure

This study employed a cross-sectional observational design using secondary data from the Neuroscience in Psychiatry Network (NSPN) dataset (Kiddle et al., 2018). This study recruited from diverse sources in Cambridge and London in the United Kingdom, including the NIHR Primary Care Research Network, schools, Further Education Colleges, and advertisements across Greater London, Cambridgeshire, and Peterborough between 2012 and 2017. The study included individuals aged 14 to 25 while excluding those receiving psychiatric treatment, with substance dependence, neurological disorders, traumatic head injuries, or treatment for learning disabilities.

In the present study, the sample consisted of 789 participants, with 365 adolescents (aged 14–17) and 424 young adults (aged 18–25) who provided baseline data. *A priori* power analysis using G*Power (Faul et al., 2009) determined that 125 participants were required for multiple linear regression with small-to-medium effects, while 602 were needed for small effects. With 365 adolescents and 424 young adults, this study had sufficient power to detect small-to-medium effects but was underpowered for very small effects.

Additionally, a Monte Carlo simulation was conducted to assess statistical power for detecting mediation effects in structural equation modelling (Muthén & Muthén, 2002). The results indicated that the current sample size was adequate for detecting small-to-medium indirect effects.

Ethical considerations

The data used in this study was collected by the NSPN Consortium, with ethics approval granted by the Cambridge Central Research Ethics Committee (reference number: 12/EE/0250). In the original study, participants provided consent for their data to be anonymised and used by researchers for future research. Confidentiality measures were taken, and all identifying information was removed from the dataset, ensuring participant privacy and GDPR and Data Protection Act 2018 compliance.

The anonymous dataset was obtained from the NSPN website, with data access approved by the NSPN research team in accordance with their established data access procedures. In line with UEA secondary data policies, no further ethical approval was required for the use of highly anonymous secondary data.

Measures

Childhood Trauma Questionnaire Short Form (CTQ-SF; Bernstein et al., 2003). The CTQ-SF was used to assess participants' self-report exposure to childhood traumatic experiences. The scale comprised 28 items divided into five subscales evaluating the different types of childhood trauma: emotional abuse, physical abuse, sexual abuse, emotional neglect, and physical neglect. Participants were asked to rate the frequency of their experience on a 5-point Likert scale, ranging from "never true" to "very often true", based on their experiences of growing up as a child and a teenager. The CTQ-SF was found to have good psychometric properties, including substantial to excellent internal consistencies, significant one-year test-retest reliability, and convergent validity in community and clinical samples of adolescents aged 14 and above (Hagborg et al., 2022). In the present study, the total score of the CTQ-SF scale

was used as a continuous variable for data analysis. The scale demonstrated good internal consistency, with a Cronbach's alpha of 0.89.

Body Mass Index (BMI). For participants aged 18–25, BMI was calculated using participants' height and weight measurements with a precision of 0.1 cm and 0.1 kg, respectively. BMI was calculated using the formula: BMI = kg/m2. While BMI was used as a continuous variable in data analyses, standard adult BMI categories are as follows: Underweight (BMI < 18.5), Normal weight (BMI = 18.5-24.9), Overweight (BMI = 25-29.9), and Obesity (BMI > 30).

BMI and zBMI are two related but distinct measures used to assess weight outcomes in children and adolescents. BMI typically ranges from about 15 to 40 for most people, while zBMI typically ranges from -3 to +3, with 0 representing the average (50th percentile) for a child's age and sex. For participants aged 14–17, BMI z-scores (zBMI) were calculated using the 'anthro' package in R Studio, which implements the WHO Child Growth Standards and the WHO Growth Reference 2007. We used the WHO standards for calculation and interpreted the zBMI values according to the NICE guideline thresholds: Underweight (zBMI < -2), Normal weight (-2 ≤ zBMI < +1.34), Overweight (+1.34 ≤ zBMI < +2.05), Obese (+2.05 ≤ zBMI < +2.68), Severe obesity (zBMI ≥ +2.68). While NICE guidelines recommend using the British 1990 (UK90) growth reference for clinical assessments in the UK, our approach allows for a standardised interpretation of weight outcomes across different populations (NICE, 2014).

Go/NoGo Task (GNG; Guitart-Masip et al., 2012). GNG task is a behavioural task used to assess participants' inhibitory control and response inhibition abilities. In this task,

participants were presented with stimuli and were required to respond with a “Go” response or with a “NoGo” response based on specific instructions. This study included an orthogonal condition to provide a more comprehensive assessment of cognitive and motivational processes involved in decision-making and response selection. This condition presented two contexts: an opportunity (win) context and a threat (avoid loss) context. By contrasting the propensity to act (Go response) versus the tendency to withhold the action (NoGo response) in these different contexts, the task aimed to examine reward sensitivity and learning rates about decision-making processes. In this study, the overall bias towards action was obtained from the dataset. The overall bias towards action (Go-bias) data was used as an inhibitory control measure. The higher the Go-bias, the more likely the participants act on the Go-response across all conditions, suggesting a lower inhibitory control.

The Mood and Feelings Questionnaire (MFQ; Costello & Angold, 1988). The MFQ is a 33-item questionnaire assessing depressive symptoms over the past 2 weeks, with responses rated on a 3-point scale (0 = not true, 1= sometimes, and 2 = true). Total scores range from 0 to 66, with a score ≥29 commonly used to indicate clinically significant depression. The MFQ was originally designed for use with 8- to 18-year-olds. It has demonstrated good content and criterion validity (Thabrew et al., 2018). Recent research has expanded its applicability, validating its use in young adults up to age 25 (Eyre et al., 2021).

Index of Multiple Deprivation (IMD). IMD was used as a composite measure of neighbourhood-level deprivation, encompassing socioeconomic and environmental factors. It is the official measure of relative deprivation in England, combining information from seven domains: income, employment, education, health, crime, barriers to housing and services, and

living environment. IMD provides a deprivation rank, with a rank of 1 indicating the most deprived area and the highest rank indicating the least deprived (Ministry of Housing, Communities and Local Government, 2019).

Study pre-registration

The current study has been pre-registered on OSF (https://doi.org/10.17605/OSF.IO/FR3Y9). Deviation from the pre-registration is reported in Appendix B.

Data Analysis

Analyses were performed separately for adolescents and young adult using R Studio (R Core Team, 2024). Data distribution was examined by inspecting histograms and boxplots and potential outliers were removed. The proportion of missing data was assessed for each variable. In the adolescent sample. zBMI had the highest percentage of missing data (24%). Little's MCAR test (Little, 1988) was not statistically significant, X^2 = 84, *df* = 68, *p* = .09, suggesting that the data were missing completely at random (MCAR). However, further analysis indicated that participants with missing zBMI data had significantly lower inhibitory control scores (*M* = 0.5, *SD* = 0.7) compared to those with complete zBMI data (*M* = 0.7, *SD* = 0.7), *p* = .03. This finding implies that missingness in zBMI may be associated with inhibitory control levels, potentially violating the MCAR assumption. For the young adult sample, inhibitory control and BMI had the highest percentage of missing data (10% and 9% respectively). Little's MCAR test was significant, X^2 = 104, *df* = 76, *p* = .02, indicating that data were not MCAR. Further analysis showed that participants with missing BMI data had significantly lower IMD scores (*M* = 10.1, *SD* = 7.7) compared to those with complete BMI data (*M* = 17.9, *SD* = 12.5).

This suggests that missingness in BMI is related to socioeconomic status. Given the indications that data were not MCAR, we used multiple imputations by chained equations (MICE) to manage missing data. The *mice* package (van Buuren & Groothuis-Oudshoorn, 2011) was used to generate imputed datasets. Data convergence was examined by inspecting the means and standard deviation of the imputed variables. Multiple linear regression analyses were conducted on imputed data to test Hypotheses 1 and 2. Structural equation modeling (SEM) analyses were conducted using the *lavaan* package in R (Rosseel, 2012) to examine Hypotheses 3 and 4. The *mediation* (Tingley et al., 2014) package was used to estimate the mediation effect, direct effect and total effect, by running 1000 simulations to estimate confidential intervals for these effects. We presented findings derived from the imputed data in this study.

All regression and SEMs models were adjusted for gender, age, and socioeconomic status to account for potential confounding effects. Gender was included given prior evidence that the associations between childhood maltreatment, depression, and weight outcomes differ between males and females (Sack et al., 2017; Richardson et al., 2003).

Results

Descriptive Statistics and Bivariate Correlations

The sample consisted of 365 adolescents and 424 young adults (see Table 4.1). A total of 6% of the current study sample met the criteria for obesity, which was comparable to the national statistics in the United Kingdom for the age group of 16–24 (8% obesity, 20% overweight, 72% not overweight or obese) (Baker, 2021).

Table 4.1

Sample Characteristics and Descriptive Statistics for Main Variables

Characteristics	Adolescents *n (%)*	Young Adults *n (%)*
Gender		
Female	189 (51.36%)	209 (49.29%)
Male	179 (48.64%)	215 (50.71%)
Ethnicity		
White	275 (74.73%)	315 (74.29%)
Asian/Asian British	40 (10.87%)	44 (10.38%)
Black/African/Caribbean	16 (4.35%)	24 (5.66%)
Mixed	28 (7.61%)	28 (6.60%)
Other ethnic groups	5 (1.36%)	9 (2.12%)
Decline to state	0 (0%)	2 (0.47%)
Missing or blank	4 (1.09%)	2 (0.47%)
Childhood Maltreatment		
Emotional abuse	12 (1.22%)	26 (1.83%)
Physical abuse	3 (0.31%)	15 (1.02%)
Sexual abuse	4 (0.41%)	19 (1.32%)
Emotional neglect	8 (0.81%)	27 (2.14%)
Physical neglect	9 (0.92%)	20 (2.03%)
	Mean (SD)	**Mean (SD)**
Age	15.87 (1.22)	20.98 (1.83)
Index of Multiple Deprivation	15.65 (12.08)	17.20(12.34)
zBMI/ BMI	0.32 (1.16)	23.66 (4.79)
	Mean (SD)	**Mean (SD)**
Childhood Maltreatment	30.9 (5.96)	33.27 (8.13)
Depressive Symptoms	14.9 (12.5)	15.8 (12.5)
Inhibitory Control	0.70 (0.72)	0.65 (0.79)

Note. Cutoff values for childhood maltreatment subtypes are based on Bernstein and Fink (1998): emotional abuse (≥13), physical abuse (≥10), sexual abuse (≥8), emotional neglect (≥15), and physical neglect (≥10). These reflect the moderate-to-severe classification.

A series of Pearson's correlation analyses were performed (see Tables S1 and S2 in Supporting Information). For the adolescent sample, childhood maltreatment was moderately positively corrected with depressive symptoms (r = .44, p < .01), suggesting that higher levels of childhood maltreatment were associated with increased depressive symptoms. Age showed weak but significant positive correlations with socioeconomic status (r = .17, p < .01) and childhood maltreatment (r = .17, p < .01), suggesting that older participants tended to report slightly higher levels of deprivation and maltreatment. zBMI was weakly positively correlated with both childhood maltreatment (r = .13, p < .01) and depressive symptoms (r = .18, p < .01), indicating that higher BMI was associated with slightly higher levels of childhood maltreatment and depressive symptoms. Inhibitory control showed a weak positive correlation with depressive symptoms (r = .11, p < .01), suggesting that lower inhibitory control (higher scores) was associated with higher depressive symptoms. Most other correlations were weak or non-significant, suggesting limited linear relationships between the remaining variables.

For the young adult sample, the strongest correlation was observed between childhood maltreatment and depressive symptoms, with a moderate positive relationship (r = .31, p < .01). Age showed weak but significant positive correlations with the socioeconomic status (r = .07, p < .01), depressive symptoms (r = .09, p < .01), and a moderate positive correlation with BMI (r = .17, p < .01). Notably, inhibitory control demonstrated weak negative correlations with socioeconomic status (r = -.08, p < .01) and childhood maltreatment (r = -.05, p < .05), while showing a weak positive correlation with BMI (r = .10, p < .01), suggesting that individuals with lower inhibitory control (higher scores) tend to have high BMI and lower level of socioeconomic deprivation. These findings suggest complex interrelationships among demographic factors,

childhood maltreatment and weight outcomes, warranting further investigation into potential interplay.

Hypothesis 1: Child maltreatment as a predictor of zBMI in the adolescent sample

Multiple linear regression analysis using imputed data was conducted to examine whether childhood maltreatment was a significant predictor of zBMI in the adolescent sample while controlling for gender and socioeconomic status (Table 4.2). The results showed that childhood maltreatment was significantly associated with higher zBMI (β = 0.13, $p < .05$), indicating that one standard deviation increase in CTQ–SF Total Scores was associated with a 0.12 standard deviation increase in zBMI. Gender (β = -0.19, p = .12) and IMD (β = -0.02, p = .73) did not show statistically significantly associations with zBMI.

When depressive symptoms were additionally controlled for in the regression analysis, the association between childhood maltreatment and zBMI was no longer significant (β = 0.07, p = .34). Depressive symptoms significantly explained the variances of zBMI (β = 0.13, p = .04), with higher depressive symptoms associated with higher zBMI. The effects of gender (β = -0.18, p = .18) and IMD (β = -0.01, p = .89) remained non-significant in this model.

Table 4.2
Regression Table for Adolescent Sample

Model	Variables	*β*	*SE*	*t*	*95% CI*	*p*
1	Gender	-0.19	0.12	-1.56	[-0.43, 0.05]	.12
	Socioeconomic status (IMD)	-0.02	0.06	-0.27	[-0.14, 0.10]	.78
	Childhood maltreatment (CTQ-SF)	0.13	0.06	2.14	[0.00, 0.25]	.03*
2	Gender	-0.16	0.13	-1.22	[-0.42, 0.09]	.23
	Socioeconomic status (IMD)	-0.03	0.06	-0.46	[-0.15, 0.09]	.65
	Childhood maltreatment (CTQ-SF)	0.08	0.08	1.04	[-0.07, 0.24]	.32
	Depressive symptoms (MFQ)	0.10	0.08	1.27	[-0.05, 0.24]	.22

Note. Standardized β coefficients reported. $p < .05$ (*).

Hypothesis 2: Child maltreatment as a predictor of BMI in the young adult sample

Multiple linear regression analysis was conducted to examine whether childhood maltreatment was a significant predictor of BMI in the young adult sample while controlling for gender and socioeconomic status (Table 4.3). Childhood maltreatment showed a non-significant positive association with BMI ($\beta = 0.11$, $p = .06$). Socioeconomic status was significantly associated with BMI ($\beta = 0.12$, $p = .02$), indicating that higher levels of deprivation are linked to higher BMI in young adults.

When depressive symptoms were included as a predictor in the regression model the positive relationship between socioeconomic status and BMI remained significant ($\beta = 0.12$, $p = .02$), while the effect of childhood maltreatment remained non-significant ($\beta = 0.09$, $p = .18$). Notably, neither gender nor depressive symptoms demonstrated significant associations with BMI in either model.

Table 4.3
Regression Table for Young Adult Sample

Model	Variables	*β*	*SE*	*t*	*95% CI*	*p*
1	Gender	-0.02	0.10	-0.21	[-0.22, 0.18]	.83
	Socioeconomic status (IMD)	0.12	0.05	2.30	[0.02, 0.22]	.02*
	Childhood maltreatment (CTQ-SF)	0.11	0.06	1.91	[-0.01, 0.22]	.06
2	Gender	0.00	0.10	0.04	[-0.19, 0.19]	.97
	Socioeconomic status (IMD)	0.12	0.05	2.28	[0.02, 0.22]	.02*
	Childhood maltreatment (CTQ-SF)	0.09	0.06	1.36	[-0.04, 0.22]	.18
	Depressive symptoms (MFQ)	0.02	0.06	0.35	[-0.10, 0.15]	.73

Note. Standardized β coefficients reported. $p < .05$ (*).

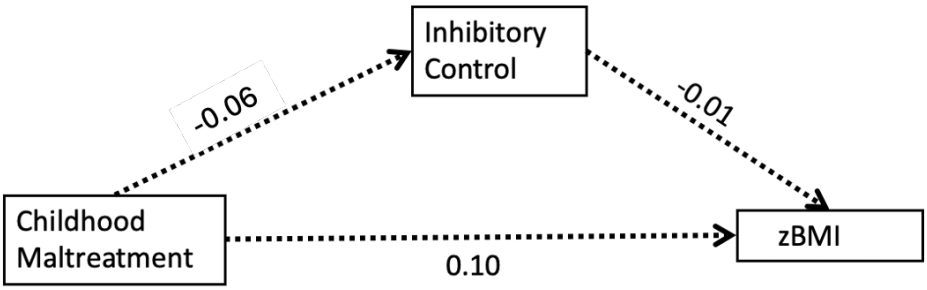
Mediation Models

To test Hypothesis 3 and 4, a series of structural equation modelling (SEM) analyses were conducted to examine whether inhibitory control and depressive symptoms mediate the relationship between childhood maltreatment and weight outcomes in both adolescent and young adult samples. Each mediation was tested in two steps: Step 1 included unadjusted models, while Step 2 included models adjusted for covariates. Only Step 2 results are presented below. For a full comparison with unadjusted models, please refer to Supplementary Table S.3. All models demonstrated excellent fit (CFT = 1.00, TLI = 1.00, RMSEA = 0.00), indicating that the hypothesised structures were consistent with the observed data.

Hypothesis 3a: The association between childhood maltreatment and zBMI will be mediated by inhibitory control in the adolescent sample

Figure 4.1

Structural equation model of childhood maltreatment, inhibitory control and zBMI



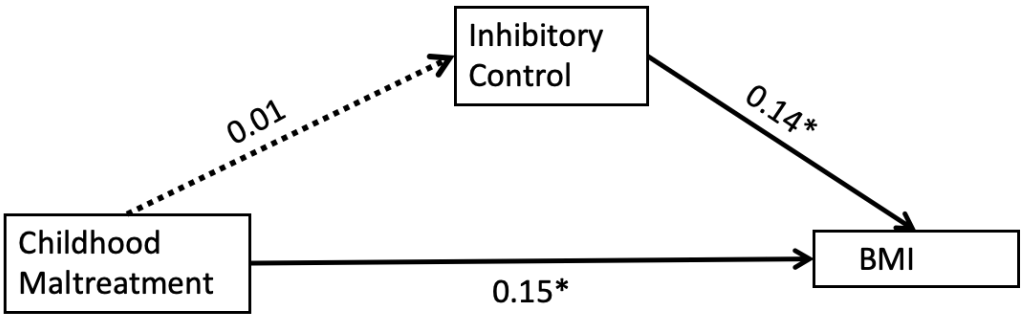
Note. Standardised path estimates are shown. The model controls for sex, age, IMD and depressive symptoms. All paths were non-significant.

The standardised results indicated that the direct effect of inhibitory control (b path: β = -.01, p = .85) and childhood maltreatment (c path: β = 0.10, p = .15) on zBMI were not statistically significant. The path from childhood maltreatment to inhibitory control was also not statistically significant (a path: β = -0.06, p = .33). The indirect effect of childhood maltreatment on BMI through inhibitory control was non-significant (β = 0.00, p = .85), suggesting that inhibitory control may not serve as a mediator in this context.

Control variables including sex, age, socioeconomic status and depressive symptoms did not show significant effects in predicting inhibitory control or BMI.

Hypothesis 3b: The association between childhood maltreatment and BMI will be mediated by inhibitory control in the young adult sample

Figure 4.2
Structural equation model of childhood maltreatment, inhibitory control and BMI



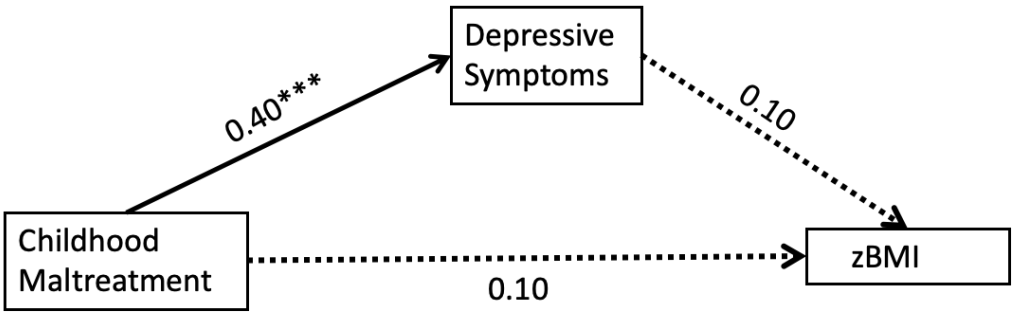
Note. Standardised path estimates are shown. The model controls for sex, age, IMD and depressive symptoms. * indicates $p < .05$.

The standardised results indicated that the direct effect of inhibitory control on BMI was statistically significant (b path: $\beta = 0.14$, $p = .01$). However, the path from childhood maltreatment to inhibitory control was not statistically significant (a path: $\beta = 0.01$, $p = .83$). The indirect effect of childhood maltreatment on BMI through inhibitory control was non-significant ($\beta = 0.00$, $p = .83$), suggesting that inhibitory control may not serve as a mediator in this context. The direct effect of childhood maltreatment on BMI was significant (c path: $\beta = 0.15$, $p = .05$; exact $p = .047$).

In terms of control variables, age had a significant positive relationship with BMI ($\beta = 0.17$, $p < .01$), whereas other control variables such as sex, socioeconomic status, and depressive symptoms did not show significant effects in predicting inhibitory control or BMI.

Hypothesis 4a: The association between childhood maltreatment and zBMI will be mediated by depressive symptoms in the adolescent sample

Figure 4.3
Structural equation model of childhood maltreatment, depressive symptoms and zBMI



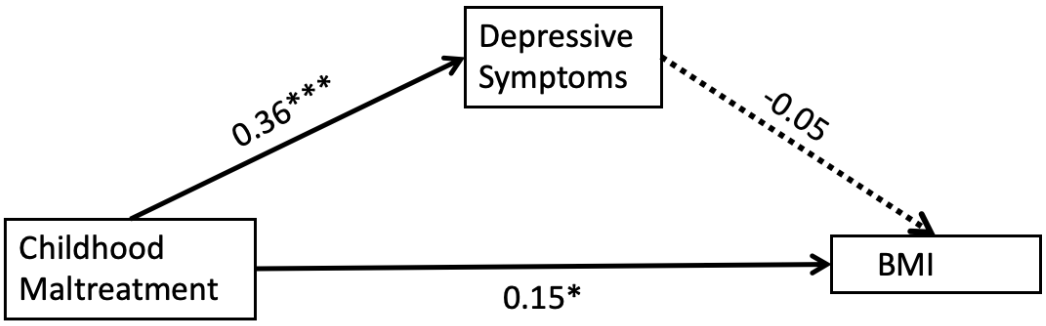
Note. Standardised path estimates are shown. The model controls for sex, age, IMD and inhibitory control. *** indicates $p < .001$.

The standardised results indicated that the direct effect of depressive symptoms (b path: $\beta = 0.10$, $p = .19$) and childhood maltreatment (c path: $\beta = 0.10$, $p = .14$) on zBMI were not statistically significant. The path from childhood maltreatment to depressive symptoms was significant (a path: $\beta = 0.40$, $p < .001$). The indirect effect of childhood maltreatment on zBMI through depressive symptoms was non-significant ($\beta = 0.04$, $p = .18$), suggesting that depressive symptoms did not serve as a mediator in this context.

Among the control variables, gender was a statistically significant predictor of depressive symptoms, with males reporting lower levels than females ($p < .001$), but it was not a statistically significant predictor of zBMI. Age, IMD, and inhibitory control were also not statistically significantly associated with either depressive symptoms or zBMI.

Hypothesis 4b: The association between childhood maltreatment and BMI will be mediated by depressive symptoms in the young adult sample

Figure 4.4
Structural equation model of childhood maltreatment, depressive symptoms and BMI



Note. Standardised path estimates are shown. The model controls for sex, age, IMD, and inhibitory control. * indicates $p < .05$. *** indicates $p < .001$.

The standardised results indicated that the direct effect of depressive symptoms (b path: $\beta = -0.05$, p = .34) on BMI was not significant. The direct effect of childhood maltreatment (c path: $\beta = 0.15$, $p = .05$; exact $p = .047$) on BMI was statistically significant. The path from childhood maltreatment to depressive symptoms was also significant (a path: $\beta = 0.36$, $p < .001$). However, the indirect effect of childhood maltreatment on BMI through depressive symptoms was non-significant ($\beta = -0.02$, $p = .35$), suggesting that depressive symptoms did not mediate this context.

In terms of control variables, neither gender nor IMD was significantly associated with depressive symptoms or BMI. However, both age ($p = .001$) and inhibitory control ($p = .01$) were

significant positive predictors of BMI, with older participants and those exhibiting lower inhibitory control reporting higher BMI.

Discussion

This study examined the relationship between childhood maltreatment and weight outcomes in adolescents and young adults, considering the potential mediating roles of depressive symptoms and inhibitory control within a community youth sample from the United Kingdom. The results indicated a positive correlation between childhood maltreatment and BMI. However, childhood maltreatment did not explain the variances of BMI when controlling for depressive symptoms in both age groups. Contrary to our hypotheses, neither depressive symptoms nor inhibitory control mediated the relationship between childhood maltreatment and BMI

The finding of a moderate positive correlation between childhood maltreatment and zBMI in the adolescent group (aged 14-17) contrasts the non-significant pooled association reported by a meta-analysis (Danese & Tan, 2014). One possible explanation is that childhood maltreatment and weight outcomes may be statistically associated, but previous meta-analyses may have focused on categorical obesity status rather than continuous measures such as BMI, limiting their power to detect subtler associations. Another potential explanation is that the association may not be linear over the course of adolescent development, as other studies have reported a time-varying pattern between childhood maltreatment and weight outcomes (Sokol et al., 2020). Broadly, our findings suggest a positive association between childhood maltreatment and zBMI in adolescents, which is consistent with earlier reviews by Elsenburg et al. (2017) and Schroeder et al. (2020). These findings also question the proposition that the

association of childhood maltreatment and weight outcomes only emerges at the age of 18 (Sokol et al., 2019).

Nevertheless, this observed association should not be interpreted as causal given the cross-sectional design. There may be many reasons why young people report both adverse life experiences and higher weight outcomes, one of the potential explanations is depressive symptoms. When it was controlled for in regression models, the strength of association between childhood maltreatment and BMI reduced substantially and was non-significant. These findings suggest that depressive symptoms may account for part of the shared variance between childhood maltreatment and weight outcomes, consistent with prior findings (Danese & Tan, 2014).

This study found limited evidence for the hypothesised mediating role of depressive symptoms in both samples. This could be due to methodological issues, such as having a non-depressed community sample which offers limited variability in depressive symptoms to detect a mediating effect. It is possible that this hypothesis may be supported for certain maltreatment subtypes and demographic subgroups. For example, Sack et al. (2017) reported that depression mediated the relationship between physical abuse and weight gain in girls, but not in boys or other maltreatment types. Richardson et al. (2003) found that depression in late adolescence was associated with obesity in early adulthood only among girls and observed a dose-response relationship between repeated depressive episodes and later weight gain. These studies highlight the importance of considering maltreatment type, demographic factors, developmental timing, dose-response relationship, and weight measurement in understanding

the relationship between childhood maltreatment, depression, and weight outcomes (Hawton et al., 2018; O'Neill et al., 2018, Richardson et al., 2003; Vámosi et al., 2009).

This study shows that Inhibitory control did not mediate the relationship between childhood maltreatment and BMI in either adolescents or young adults. One explanation is that the experimental task for inhibitory control does not involve the use of food-related stimuli, as food-related versions of cognitive tasks have stronger associations with weight outcomes (Favieri et al., 2024). However, Çakır et al. (2023) found that both working memory and inhibition significantly mediated the relationship between adverse childhood experiences and emotional eating, even when using non–food-specific tasks. These findings suggest that inhibitory control may be associated with pathways linking childhood maltreatment to disordered eating behaviours, such as emotional eating, but not necessarily to BMI directly. Future research should investigate this pathway using food-specific executive function tasks and direct measures of eating behaviour, such as disinhibition or emotional eating.

Socioeconomic status was statistically significantly associated with BMI in young adults and this association appeared independent of depressive symptoms, suggesting that environmental influence may particularly relevant as individuals transition into adulthood. While socioeconomic and environmental factors are well established correlates of weight outcomes, relatively few studies have explored how they interact with childhood maltreatment (Fleischer et al., 2021; Wallace & Krugman, 2024). More research is needed to unpack the mechanisms that underlie these associations.

Strengths and Limitations

To our knowledge, this is the first UK-based study to investigate the relationship between childhood maltreatment and BMI, while also exploring potential underlying mechanisms, using a large, representative sample inclusive of both genders. The analysis considered multiple confounders, including age, sex, socioeconomic status and depressive symptoms. In addition, the nuance of zBMI/ BMI calculation were addressed by conducting separate analyses for the adolescent and young adult sample.

Despite these strengths, several limitations should be acknowledged. While BMI is a widely used indicator of weight outcomes, it does not account for fat, lean mass, or fat distribution, which limits its ability to assess weight-related health risks. The present study also relied on a retrospective self-report to assess childhood maltreatment, which may be subject to recall bias or influenced by the current psychological state. Although the CTQ-SF questionnaire is a well-validated instrument with great psychometric properties, recent research has highlighted notable discrepancies between prospective and retrospective reports of maltreatment (e.g. Coleman et al., 2024). Another limitation relates to the use of Go/NoGo task as a proxy for inhibitory control. Although widely accepted in cognitive neuroscience, the task captures inhibition on a millisecond timescale and may have limited ecological validity in reflecting the real-world decision-making processes involved in eating and weight regulation. Furthermore, the absence of eating behaviours measures in the current study limits the interpretability of inhibitory control findings in this context. Lastly, as this is a cross-sectional study, we cannot infer directionality or causality of the observed associations. Longitudinal studies are needed to clarify temporal order and potential causal mechanisms. In addition, the

limited number of participants meeting the threshold for each type of maltreatment also constrained our ability to conduct analyses by maltreatment subtypes.

Future Research and Clinical Implications

Some researchers advocate for alternative measures such as waist-to-hip ratio or waist circumferences, which may offer better estimates of central adiposity and associated cardiometabolic risks (Ashwell et al., 2012; Wells & Fewtrell, 2006). Future studies would benefit from incorporating such measures to capture the individual differences in weight related outcomes. In addition, future research should incorporate both cognitive and self-report measures that are directly relevant to food-related impulsivity, inhibitory control and self-regulation to reflect real-world processes. Moreover, future work would also be benefited by using longitudinal study design to examine growth curves and possible underlying mechanisms. Lastly, in the mediation models, we did not employ bootstrapped confidence intervals to statistically verify the significance of the indirect effects. While standard errors were estimated, future research could build on these findings by using bootstrapping methods, which offer more reliable inference.

Regarding clinical implications, the findings suggest that childhood maltreatment may not be a strong distal predictor of BMI in young people based in the community in the UK. Environmental factors such as socioeconomic conditions appear more relevant to BMI in young adults. For clinicians who are adopting a biopsychosocial approach to formulate a young person's weight issue, it may be helpful to consider the impact of childhood maltreatment and wider environmental factors on a case-to-case basis, without assuming this association being always present. For example, they can explore with the young person how their perception of

childhood maltreatment and socioeconomic status may affect their attitude to food consumption, self-concepts, and weight management behaviours.

Within the service context, the NHS Long Term Plan commits sustained investment in prevention and specialist weight-management pathways, providing a policy context for improving weight-management services (NHS England, 2019). However, there is limited published evidence that routine enquiry about childhood maltreatment is embedded within UK weight-management pathways; reviews note workforce constraints on delivering psychological assessment and support despite acknowledgement of the importance of psychological input in British Obesity and Metabolic Surgery Society guidance (Hazlehurst et al., 2020). Accordingly, services could incorporate brief trauma-informed enquiry during routine assessment where appropriate to help identify when maltreatment-related factors are clinically relevant in everyday care.

Conclusion

This study examined the relationship between childhood maltreatment and BMI in a community sample of adolescents and young adults in the United Kingdom, considering inhibitory control and depressive symptoms as potential mediators. While childhood maltreatment was positively correlated with BMI, it did not remain statistically significant after accounting for depressive symptoms in both age groups. Socioeconomic status was statistically significantly associated with BMI in young adults. Contrary to our hypotheses, neither depressive symptoms nor inhibitory control mediated the relationship between childhood maltreatment and weight outcomes. These findings highlight the importance of socioeconomic

factors and suggest the need for longitudinal research stratified by maltreatment subtype and gender.

CRediT authorship contribution statement

Alyse Yu Hung: Conceptualisation; Methodology; Research Design; Project Administration; Literature Review; Data Curation; Formal Analysis; Interpretation; Writing – Original Draft; Writing – Review & Editing.

Richard Meiser-Stedman: Conceptualisation; Methodology; Supervision; Writing – Review & Editing.

Saber Sami: Conceptualisation; Supervision; Writing – Review & Editing.

Kenny Chiu: Conceptualisation; Methodology; Supervision; Writing – Review & Editing.

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Author statement

We confirm that this work is original and has not been published elsewhere, nor is it currently under consideration for publication elsewhere.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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References

Allom, V., Mullan, B., & Hagger, M. (2016). Does inhibitory control training improve health behaviour? A meta-analysis. *Health Psychology Review*, *10*(2), 168-186.

Ashwell, M., Gunn, P., & Gibson, S. (2012). Waist-to-height ratio is a better screening tool than waist circumference and BMI for adult cardiometabolic risk factors: Systematic review and meta-analysis. *Obesity Reviews*, *13*(3), 275–286.

Baker, C. (2021, August 9). *Obesity statistics* (House of Commons Library Research Briefing No. CBP-3336). UK Parliament.

Bernstein, D. P., Fink, L., Handelsman, L., & Foote, J. (1998). Childhood trauma questionnaire. *Assessment of family violence: A handbook for researchers and practitioners.*

Bernstein, D. P., Stein, J. A., Newcomb, M. D., Walker, E., Pogge, D., Ahluvalia, T., Stokes, J., Handelsman, L., Medrano, M., & Desmond, D. (2003). Development and validation of a brief screening version of the Childhood Trauma Questionnaire. *Child Abuse & Neglect*, *27*(2), 169–190.

Brown, S., Mitchell, T. B., Fite, P. J., & Bortolato, M. (2017). Impulsivity as a moderator of the associations between child maltreatment types and body mass index. *Child Abuse & Neglect*, *67*, 137-146.

Çakır, R., Topuz, A. G., & Alpay, E. H. (2024). Working memory and inhibition as mediators in the relationship between adverse childhood experiences and emotional eating. *Psychological Reports*, 00332941241311509.

Coleman, O., Baldwin, J. R., Moffitt, T. E., Arseneault, L., Fisher, H. L., Rose-Clarke, K., & Danese, A. (2024). Why do prospective and retrospective measures of childhood

maltreatment differ? Qualitative analyses in a cohort study. *Child Abuse & Neglect*, *157*, 107070.

Costello, E. J., & Angold, A. (1988). Scales to assess child and adolescent depression: Checklists, screens, and nets. *Journal of the American Academy of Child & Adolescent Psychiatry*, *27*(6), 726–737.

Diamond, A. (2013). Executive functions. *Annual review of psychology*, *64*(1), 135-168.

Danese, A., & Tan, M. (2014). Childhood maltreatment and obesity: Systematic review and meta-analysis. *Molecular Psychiatry*, *19*(5), 544–554.

De Klerk, M. T., Smeets, P. A. M., & La Fleur, S. E. (2023). Inhibitory control as a potential treatment target for obesity. *Nutritional Neuroscience*, *26*(5), 429-444.

Elsenburg, L. K., van Wijk, K. J., Liefbroer, A. C., & Smidt, N. (2017). Accumulation of adverse childhood events and overweight in children: a systematic review and meta-analysis. *Obesity*, *25*(5), 820-832.

Eyre, O., Jones, R. B., Agha, S. S., Wootton, R. E., Thapar, A. K., Stergiakouli, E., Langley, K., Collishaw, S., Thapar, A., & Riglin, L. (2021). Validation of the short Mood and Feelings Questionnaire in young adulthood. *Journal of Affective Disorders*, *294*, 883–888.

Faul, F., Erdfelder, E., Buchner, A., & Lang, A.-G. (2009). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods*, *41*(4), 1149–1160.

Favieri, F., Tambelli, R., Chen, E., & Casagrande, M. (2024). Self-regulation in eating behaviors: the role of executive function in response to food stimuli. *Nutrients*, *16*(14), 2318.

Fosse, G. K., & Holen, A. (2006). Childhood maltreatment in adult female psychiatric outpatients with eating disorders. *Eating Behaviors, 7*(4), 404-409.

Gilbert, R., Widom, C. S., Browne, K., Fergusson, D., Webb, E., & Janson, S. (2009). Burden and consequences of child maltreatment in high-income countries. *The Lancet*, *373*(9657), 68-81.

Guitart-Masip, M., Huys, Q. J., Fuentemilla, L., Dayan, P., Duzel, E., & Dolan, R. J. (2012). Go and no-go learning in reward and punishment: interactions between affect and effect. *Neuroimage*, *62*(1), 154-166.

Hagborg, J. M., Kalin, T., & Gerdner, A. (2022). The Childhood Trauma Questionnaire—Short Form (CTQ-SF) used with adolescents – methodological report from clinical and community samples. *Journal of Child & Adolescent Trauma*, *15*(4), 1199–1213.

Hawton, K., Norris, T., Crawley, E., & Shield, J. P. H. (2018). Is Child Abuse Associated with Adolescent Obesity? A Population Cohort Study. *Childhood Obesity*, *14*(2), 106–113.

Hazlehurst, J. M., Logue, J., Parretti, H. M., Abbott, S., Brown, A., Pournaras, D. J., & Tahrani, A. A. (2020). Developing integrated clinical pathways for the management of clinically severe adult obesity: a critique of NHS England policy. *Current obesity reports*, *9*(4), 530-543.

Heim, C., Nater, U. M., Maloney, E., Boneva, R., Jones, J. F., & Reeves, W. C. (2009). Childhood trauma and risk for chronic fatigue syndrome: association with neuroendocrine dysfunction. *Archives of General Psychiatry*, 66(1), 72-80

Humphreys, K. L., LeMoult, J., Wear, J. G., Piersiak, H. A., Lee, A., & Gotlib, I. H. (2020). Child maltreatment and depression: A meta-analysis of studies using the Childhood Trauma Questionnaire. *Child Abuse & Neglect*, *102*, 104361.

Jones, A., Di Lemma, L. C., Robinson, E., Christiansen, P., Nolan, S., Tudur-Smith, C., & Field, M. (2016). Inhibitory control training for appetitive behaviour change: A meta-analytic investigation of mechanisms of action and moderators of effectiveness. *Appetite*, *97*, 16-28.

Kiddle, B., Inkster, B., Prabhu, G., Moutoussis, M., Whitaker, K. J., Bullmore, E. T., ... & Jones, P. B. (2018). Cohort profile: the NSPN 2400 Cohort: A developmental sample supporting the Wellcome Trust Neuroscience in Psychiatry Network. *International Journal of Epidemiology*, *47*(1), 18-19g.

Kulendran, M., Vlaev, I., Gamboa, P., & Darzi, A. (2017). The role of impulsivity in obesity as measured by inhibitory control: a systematic review. *Medical Research Archives*, *5*(8).

Lee, V., & Hoaken, P. N. (2007). Cognition, emotion, and neurobiological development: Mediating the relation between maltreatment and aggression. *Child Maltreatment*, 12(3), 281-298.

Little, R. J. A. (1988). A Test of Missing Completely at Random for Multivariate Data with Missing Values. *Journal of the American Statistical Association*, *83*(404), 1198–1202.

Liu, R. T. (2019). Childhood maltreatment and impulsivity: A meta-analysis and recommendations for future study. *Journal of Abnormal Child Psychology*, *47*(2), 221-243.

Lo, C. C., & Cheng, T. C. (2007). The impact of childhood maltreatment on young adults' substance abuse. *The American Journal of Drug and Alcohol Abuse, 33*(1), 139-146.

Luppino, F. S., de Wit, L. M., Bouvy, P. F., Stijnen, T., Cuijpers, P., Penninx, B. W., & Zitman, F. G. (2010). Overweight, obesity, and depression: a systematic review and meta-analysis of longitudinal studies. *Archives of General Psychiatry*, *67*(3), 220-229.

Ministry of Housing, Communities & Local Government. (2019). *English indices of deprivation 2019: Technical report*. https://www.gov.uk/government/statistics/english-indices-of-deprivation-2019

Muthén, L. K., & Muthén, B. O. (2002). How to use a Monte Carlo study to decide on sample size and determine power. *Structural Equation Modeling: A Multidisciplinary Journal*, *9*(4), 599–620.

National Institute for Health and Care Excellence. (2014). *Obesity: Identification, Assessment and Management* (NICE Guideline No. CG189). https://www.nice.org.uk/guidance/cg189

NHS England. (2019). *The NHS Long Term Plan*. NHS England. https://www.longtermplan.nhs.uk/

O'Neill, A., Beck, K., Chae, D., Dyer, T., He, X., & Lee, S. (2018). The pathway from childhood maltreatment to adulthood obesity: The role of mediation by adolescent depressive symptoms and BMI. *Journal of Adolescence*, *67*, 22–30.

Park, S. C., Kato, T. A., Lee, J. H., & Yu, S. H. (2025). Exploring the Bidirectional Relationship Between Depression and Obesity. *Endocrinology and Metabolism Clinics*, *54*(1), 193-206.

R Core Team. (2024). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing. https://www.R-project.org/

Richardson, L. P., Davis, R., Poulton, R., McCauley, E., Moffitt, T. E., Caspi, A., & Connell, F. (2003). A longitudinal evaluation of adolescent depression and adult obesity. *Archives of Pediatrics & Adolescent Medicine*, *157*(8), 739–745.

Rosseel, Y. (2012). *lavaan*: An R package for structural equation modeling. *Journal of Statistical Software, 48*(2), 1–36.

Sacks, R. M., Takemoto, E., Andrea, S., Dieckmann, N. F., Bauer, K. W., & Boone-Heinonen, J. (2017). Childhood maltreatment and BMI trajectory: The mediating role of depression. *American Journal of Preventive Medicine*, *53*(5), 625–633.

Schroeder, K., Schuler, B. R., Kobulsky, J. M., & Sarwer, D. B. (2021). The association between adverse childhood experiences and childhood obesity: A systematic review. *Obesity Reviews*, *22*(7), e13204.

Sokol, R. L., Ennett, S. T., Shanahan, M. E., Gottfredson, N. C., Poti, J. M., Halpern, C. T., & Fisher, E. B. (2019). Maltreatment experience in childhood and average excess body mass from adolescence to young adulthood. *Child Abuse & Neglect*, *96*, 104070.

Thabrew, H., Stasiak, K., Bavin, L., Frampton, C., & Merry, S. (2018). Validation of the Mood and Feelings Questionnaire (MFQ) and Short Mood and Feelings Questionnaire (SMFQ) in New Zealand help-seeking adolescents. *International Journal of Methods in Psychiatric Research*, *27*(3), e1610.

Tingley, D., Yamamoto, T., Hirose, K., Keele, L., & Imai, K. (2014). Mediation: R package for causal mediation analysis. *Journal of Statistical Software*, *59*, 1–38.

Vámosi, M., Heitmann, B. L., & Kyvik, K. O. (2010). The relation between an adverse psychological and social environment in childhood and the development of adult obesity: A systematic literature review. *Obesity Reviews*, *11*(3), 177–184.

Van Buuren, S., & Groothuis-Oudshoorn, K. (2011). mice: Multivariate imputation by chained equations in R. *Journal of Statistical Software*, *45*, 1–67.

Wallace, C., & Krugman, R. (2024). More than what you eat: A review on the association between childhood maltreatment and elevated adult BMI. *Current Nutrition Reports*, *13*(3), 377–381.

Wells, J. C. K., & Fewtrell, M. S. (2006). Measuring body composition. *Archives of Disease in Childhood*, *91*(7), 612–617.

Supplementary Materials

Table S.1

Correlational matrix of the imputed data for the adolescent sample

Variable	*M*	*SD*	1	2	3	4	5
1. Age	15.88	1.23					
2. IMD	15.61	11.90	.17** [.12, .21]				
3. Childhood Maltreatment	30.75	5.51	.17** [.12, .21]	.01 [-.04, .05]			
4. Depressive symptoms	13.49	11.23	.09** [.04, .13]	.02 [-.03, .06]	.44** [.41, .48]		
5. Inhibitory Control	0.69	0.73	.00 [-.05, .05]	.01 [-.03, .06]	-.01 [-.06, .03]	.11** [.07, .16]	
6. zBMI	0.35	1.18	.01 [-.03, .06]	-.01 [-.05, .04]	.13** [.08, .17]	.18** [.14, .23]	.03 [-.02, .07]

Note. M and *SD* are used to represent mean and standard deviation, respectively. $p < .05$ (*), $p < .01$ (**).

Table S.2

Correlational matrix of the imputed data for the young adult sample

Variable	*M*	*SD*	1	2	3	4	5
1. Age	20.98	1.83					
2. IMD	17.19	12.31	.07** [.03, .11]				
3. Childhood Maltreatment	33.38	8.17	.03 [-.01, .08]	.12** [.08, .16]			
4. Depressive symptoms	14.31	10.89	.09** [.04, .13]	.10** [.05, .14]	.31** [.27, .35]		
5. Inhibitory Control	0.64	0.79	-.01 [-.06, .03]	-.08** [-.12, -.03]	-.05* [-.09, -.01]	.01 [-.04, .05]	
6. BMI	23.64	4.77	.17** [.12, .21]	.13** [.09, .17]	.11** [.07, .15]	.06** [.02, .10]	.10** [.05, .14]

Note. M and *SD* are used to represent mean and standard deviation, respectively. $p < .05$ (*), $p < .01$ (**).

Table S.3

Structural Equation Models Testing Mediation Effects

		Step 1 (Unadjusted)				Step 2 (Adjusted)			
Path		***β***	***SE***	***p***	**95%CI**	***β***	***SE***	***p***	**95%CI**
Childhood Maltreatment (CM) → Inhibitory Control (IC) → zBMI									
a	CM → IC	-0.01	0.05	.90	[-0.11, 0.10]	-0.06	0.06	.33	[-0.18, 0.06]
b	IC → zBMI	0.01	0.06	.88	[-0.11, 0.13]	-0.01	0.06	.85	[-0.13, 0.11]
c	CM → zBMI	0.14	0.06	.02*	[0.03, 0.25]	0.10	0.07	.15	[-0.04, 0.23]
Indirect	(ab)*	0.00	0.00	.92	[-0.01, 0.01]	0.00	0.00	.85	[-0.01, 0.01]
Total	c+(a*b)	0.14	0.06	.02*	[0.03, 0.25]	0.10	0.07	.14	[-0.03, 0.23]
Childhood Maltreatment (CM) → Inhibitory Control (IC) → BMI									
a	CM → IC	-0.03	0.05	.65	[-0.13, 0.08]	0.01	0.06	.83	[-0.11, 0.14]
b	IC → BMI	0.11	0.05	.04*	[0.01, 0.22]	0.14	0.05	.01*	[0.04, 0.25]
c	CM → BMI	0.11	0.07	.13	[-0.03, 0.26]	0.15	0.08	.05*	[0.00, 0.30]
Indirect	(ab)*	-0.00	0.01	.65	[-0.02, 0.02]	0.00	0.01	.83	[-0.02, 0.02]
Total	c+(a*b)	0.11	0.07	.14	[-0.04, 0.25]	0.15	0.08	.04*	[0.00, 0.30]
Childhood Maltreatment (CM) → Depressive Symptoms (DS) → zBMI									
a	CM → DS	0.45	0.06	< .001***	[0.34, 0.56]	0.40	0.06	< .001***	[0.29, 0.52]
b	DS → zBMI	0.12	0.06	.07	[-0.01, 0.24]	0.10	0.08	.19	[-0.05, 0.24]
c	CM → zBMI	0.08	0.07	.23	[-0.05, 0.21]	0.10	0.07	.14	[-0.03, 0.23]
Indirect	(ab)*	0.05	0.03	.07	[-0.01, 0.11]	0.04	0.03	.18	[-0.02, 0.10]
Total	c+(a*b)	0.13	0.05	.02*	[0.02, 0.24]	0.14	0.06	.01*	[0.03, 0.25]
Childhood Maltreatment (CM) → Depressive Symptoms (DS) → BMI									

a	CM → DS	0.35	0.06	< .001***	[0.23, 0.46]	0.36	0.06	< .001***	[0.23, 0.49]
b	DS → BMI	0.00	0.05	.94	[-0.10, 0.11]	-0.05	0.06	.34	[-0.16, 0.05]
c	CM → BMI	0.13	0.07	.07	[-0.01, 0.28]	0.15	0.08	.05*	[0.00, 0.30]
Indirect	(ab)*	0.00	0.02	.94	[-0.03, 0.04]	-0.02	0.02	.35	[-0.06, 0.02]
Total	c+(a*b)	0.13	0.07	.06	[-0.01, 0.28]	0.13	0.08	.08	[-0.02, 0.28]

Note. Standardized β coefficients reported. *p*-values are rounded to 2 decimal places. Exact *p*-values were used to estimate statistical significance. Step 2 adjusted for sex, age, IMD, depressive symptoms for inhibitory control models; Step 2 adjusted for sex, age, IMD, inhibitory control for depressive symptoms models. $p < .05$ (*), $p < .01$ (**), $p < .001$ (***).

Chapter Five: Extended Discussion and Critical Evaluation

Main Findings

This thesis portfolio consisted of two interconnected components that examined the relationship between childhood maltreatment and weight outcomes in young people up to 25 years of age. The meta-analysis results suggested that most types of childhood maltreatment were not significantly associated with obesity, with the exception of sexual abuse. The relationship between childhood maltreatment and obesity was generally not moderated by factors such as publication year, age group, study quality, and study design.

The empirical findings showed a general positive correlation between combined childhood maltreatment and standardised Body Mass Index (zBMI; BMI-for-age-and-sex z-score) and Body Mass Index (BMI; kg/m^2) in both adolescents and young adults. However, combined childhood maltreatment did not remain statistically significantly associated with BMI after controlling for key covariates such as depressive symptoms, age, and gender. Neither depressive symptoms nor inhibitory control were found to mediate the relationship between childhood maltreatment and BMI. In contrast, socioeconomic status was statistically significantly associated with BMI in young adults.

These findings highlighted the importance of considering developmental timing and maltreatment subtypes, suggesting that the associations of specific forms of childhood maltreatment on weight outcomes may emerge during adolescence and early adulthood. The effect of childhood maltreatment on weight outcomes may operate through indirect or intermediate pathways, such as psychological (e.g. emotional coping), environmental (e.g. social disadvantage), cognitive (e.g. body appraisal), physiological (e.g. HPA axis dysregulation

and cortisol levels), and developmental factors (e.g. dose-response effects, type and timing of exposure). These findings also underscore the need to adopt a multidimensional perspective when examining the relationship between childhood maltreatment and weight outcomes, particularly the increasing role of environmental factors as individuals transition into young adulthood.

Strengths and Limitations

Systematic Review

This thesis portfolio is strengthened by its multi-method design, integrating both a systematic review with meta-analysis and an empirical study. For the systematic review and meta-analysis, one key strength is the pre-registration of the study in PREOSPERO, which helps to minimise biases, increase transparency, and prevent duplication of research efforts (Stewart et al., 2012). Furthermore, the separate analysis of maltreatment subtypes helped to clarify mixed findings in the existing literature by enabling the identification of specific forms of maltreatment that may be more strongly associated with weight outcomes in adolescents and young adults. Sensitivity analyses were also conducted for outliers and converted effect sizes, which helped to reduce biases and improve understanding of the data structure.

Nevertheless, several limitations should be noted. Due to stratification by maltreatment type, each analysis included only a small number of studies. Most analyses included less than 10 studies, therefore funnel plots were not conducted due to concerns about the reliability and interpretability of publication bias assessment with such limited numbers (Borenstein et al., 2009). Moreover, the majority of included studies were conducted in the United States,

reducing the generalisability of findings to other cultural settings. In addition, most studies focused on non-clinical community samples. While this enhances ecological validity, it limits the ability to generalise findings to clinical populations or to detect effects that may be more pronounced in clinical settings.

Empirical Study

One of the key strengths of the empirical study was the representativeness of the sample. The distribution of weight outcomes closely matched the national statistics for individuals aged 16-25 in the United Kingdom (Baker, 2021), strengthening the generalisability of findings at the community level. This study also included an appropriate sample size, 365 adolescents and 424 young adults, with a balanced number of male and female respondents. To our knowledge, this is among the first United Kingdom-based studies to examine the relationship between childhood maltreatment and BMI in a community sample of adolescents and young adults across genders. This helped to address both geographical and developmental gaps in the literature, capturing a key transitional period in which weight-related risks may begin to emerge. Furthermore, the investigation focused on five common maltreatment types rather than broader adverse childhood experiences, and incorporated multiple environmental, psychological, and cognitive factors, contributing to a more nuanced developmentally sensitive understanding of potential mechanisms.

However, several limitations should be noted. Although BMI is a widely used indicator of weight, it does not account for fat, lean mass, or fat distribution, thereby limiting its ability to assess weight-related health risks. In addition, while the Go/NoGo task is commonly used in

cognitive neuroscience, it captures inhibition on a millisecond timescale and may have limited ecological validity in capturing real-world decision-making around eating and weight regulation. Lastly, the cross-sectional design and the limited number of participants meeting the threshold for each maltreatment subtype restricted the feasibility of stratified analyses and limited the ability to draw causal conclusions.

Implications

The findings of the thesis portfolio have important implications for clinical psychology, youth mental health, and public health. Specifically, they suggest that the relationship between childhood maltreatment and weight outcomes may vary by maltreatment types. This highlights the need for differentiated theoretical models that account for the distinct psychological, cognitive, behavioural, and biological mechanisms associated with each type of maltreatment.

From the community and public health perspective in the United Kingdom, these findings suggest that risk detection strategies should be sensitive to the combined influence of biological, psychological, sociological, and environmental factors. In particular, the role of socioeconomic disadvantage in shaping physical health outcomes during the transition from adolescence to young adulthood. Environmental influence may play a more decisive role in shaping weight trajectories than maltreatment alone in this context.

Nevertheless, clinically speaking our findings caution against making assumptions about a direct causal relationship between childhood maltreatment and weight outcomes. While maltreatment may be a contributing factor, it likely operates through indirect and complex pathways such as emotional coping and stress regulation. For practitioners working with

adolescents and young adults, a case-by-case approach remains essential. Clinicians are encouraged to explore with the young person how their past experiences and current environment context, including perceived adversity and socioeconomic circumstances, may affect their attitude toward food, body image, and weight related behaviours.

Future Research Directions

Future research should further explore how the timing of childhood maltreatment interacts with maltreatment type to shape weight-related risk trajectories. To clarify underlying mechanisms, studies should prioritise the integration of psychological (e.g. depression), physiological (e.g. cortisol levels), and environmental (e.g. socioeconomic status) measures. Incorporating food-related cognitive and behavioural factors would further enhance ecological validity and provide a more comprehensive understanding of the pathways linking maltreatment to weight outcomes. In addition, longitudinal study designs with at least three time points would help capture the temporal dynamics involved. More United Kingdom based studies using population representative dataset are particularly important to improve the generalisability and relevance of research in this area.

Conclusion

This thesis portfolio contributes to a growing body of literature on the complex relationship between childhood maltreatment and weight outcomes in young people. Through a multi-method approach, our findings suggest that maltreatment may be associated with weight outcomes as a distal factor, potentially through indirect and intermediate pathways. This highlights the importance of considering maltreatment subtypes, developmental timing, and broader biopsychosocial factors when examining the relationship.

References

Allom, V., Mullan, B., & Hagger, M. (2016). Does inhibitory control training improve health behaviour? A meta-analysis. *Health Psychology Review*, *10*(2), 168-186.

Ashwell, M., Gunn, P., & Gibson, S. (2012). Waist-to-height ratio is a better screening tool than waist circumference and BMI for adult cardiometabolic risk factors: Systematic review and meta-analysis. *Obesity Reviews*, *13*(3), 275–286.

Baker, C. (2021, August 9). *Obesity Statistics* (House of Commons Library Research Briefing No. CBP-3336). UK Parliament.

Balduzzi, S., Rücker, G., & Schwarzer, G. (2019). *meta*: An R package for meta-analysis. *R package version 4.9-7.*

Baumeister, R. F., & Newman, L. S. (1994). Self-regulation of cognitive inference and decision processes. *Personality and Social Psychology Bulletin*, *20*(1), 3-19.

Bennett, D. S., Wolan Sullivan, M., Thompson, S. M., & Lewis, M. (2010). Early child neglect: Does it predict obesity or underweight in later childhood? *Child Maltreatment*, *15*(3), 250-254.

Bernstein, D. P., Fink, L., Handelsman, L., & Foote, J. (1998). Childhood trauma questionnaire. *Assessment of Family Violence: A handbook for researchers and practitioners.*

Bernstein, D. P., Stein, J. A., Newcomb, M. D., Walker, E., Pogge, D., Ahluvalia, T., Stokes, J., Handelsman, L., Medrano, M., & Desmond, D. (2003). Development and validation of a brief screening version of the Childhood Trauma Questionnaire. *Child Abuse & Neglect*, *27*(2), 169–190.

Borenstein, M., Cooper, H., Hedges, L., & Valentine, J. (2009). Effect sizes for continuous data. *The handbook of research synthesis and meta-analysis*, *2*, 221-235.

Bevan, E., & Higgins, D. J. (2002). Is domestic violence learned? The contribution of five forms of child maltreatment to men's violence and adjustment. *Journal of Family Violence*, *17*, 223-245.

Brown, S., Mitchell, T. B., Fite, P. J., & Bortolato, M. (2017). Impulsivity as a moderator of the associations between child maltreatment types and body mass index. *Child Abuse & Neglect*, *67*, 137-146.

Çakır, R., Topuz, A. G., & Alpay, E. H. (2024). Working memory and inhibition as mediators in the relationship between adverse childhood experiences and emotional eating. *Psychological Reports*, 00332941241311509.

Coleman, O., Baldwin, J. R., Moffitt, T. E., Arseneault, L., Fisher, H. L., Rose-Clarke, K., & Danese, A. (2024). Why do prospective and retrospective measures of childhood maltreatment differ? Qualitative analyses in a cohort study. *Child Abuse & Neglect*, *157*, 107070.

Costello, E. J., & Angold, A. (1988). Scales to assess child and adolescent depression: Checklists, screens, and nets. *Journal of the American Academy of Child & Adolescent Psychiatry*, *27*(6), 726–737.

Danese, A., & Tan, M. (2014). Childhood maltreatment and obesity: Systematic review and meta-analysis. *Molecular Psychiatry*, *19*(5), 544–554.

De Klerk, M. T., Smeets, P. A. M., & La Fleur, S. E. (2023). Inhibitory control as a potential treatment target for obesity. *Nutritional Neuroscience*, *26*(5), 429-444.

Duncan, A. E., Sartor, C. E., Jonson-Reid, M., Munn-Chernoff, M. A., Eschenbacher, M. A., Diemer, E. W., ... & Heath, A. C. (2015). Associations between body mass index, post-traumatic stress disorder, and child maltreatment in young women. *Child Abuse & Neglect*, *45*, 154-162.

Egger, M., Davey Smith, G., Schneider, M., & Minder, C. (1997). Bias in meta-analysis detected by a simple, graphical test. *BMJ, 315*(7109), 629–634.

Elsenburg, L. K., van Wijk, K. J., Liefbroer, A. C., & Smidt, N. (2017). Accumulation of adverse childhood events and overweight in children: a systematic review and meta-analysis. *Obesity*, *25*(5), 820-832.

Eyre, O., Jones, R. B., Agha, S. S., Wootton, R. E., Thapar, A. K., Stergiakouli, E., Langley, K., Collishaw, S., Thapar, A., & Riglin, L. (2021). Validation of the short Mood and Feelings Questionnaire in young adulthood. *Journal of Affective Disorders*, *294*, 883–888.

Faul, F., Erdfelder, E., Buchner, A., & Lang, A.-G. (2009). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods*, *41*(4), 1149–1160.

Favieri, F., Tambelli, R., Chen, E., & Casagrande, M. (2024). Self-Regulation in eating behaviors: The role of executive function in response to food stimuli. *Nutrients*, *16*(14), 2318

Fosse, G. K., & Holen, A. (2006). Childhood maltreatment in adult female psychiatric outpatients with eating disorders. *Eating Behaviors,* 7(4), 404-409.

Fredrickson, B. L., & Roberts, T. A. (1997). Objectification theory: Toward understanding women's lived experiences and mental health risks. *Psychology of Women Quarterly*, *21*(2), 173-206.

Fuemmeler, B. F., Dedert, E., McClernon, F. J., & Beckham, J. C. (2009). Adverse childhood events are associated with obesity and disordered eating: results from a US population-based survey of young adults. *Journal of Traumatic Stress: Official Publication of The International Society for Traumatic Stress Studies, 22*(4), 329-333.

Fu, R., Gartlehner, G., Grant, M., Shamliyan, T., Sedrakyan, A., Wilt, T. J., ... & Lohr, K. N. (2011). *Conducting quantitative synthesis when comparing medical interventions: AHRQ and the Effective Health Care Program (Methods Guide for Comparative Effectiveness Reviews, 2011)*. Agency for Healthcare Research and Quality.

Gilbert, R., Widom, C. S., Browne, K., Fergusson, D., Webb, E., & Janson, S. (2009). Burden and consequences of child maltreatment in high-income countries. *The Lancet*, 373(9657), 68-81.

Gooding, H. C., Milliren, C., Austin, S. B., Sheridan, M. A., & McLaughlin, K. A. (2015). Exposure to violence in childhood is associated with higher body mass index in adolescence. *Child Abuse & Neglect*, *50*, 151-158.

Guitart-Masip, M., Huys, Q. J., Fuentemilla, L., Dayan, P., Duzel, E., & Dolan, R. J. (2012). Go and no-go learning in reward and punishment: interactions between affect and effect. *Neuroimage*, *62*(1), 154-166.

Haddaway, N. R., Bethel, A., Dicks, L. V., Koricheva, J., Macura, B., Petrokofsky, G., ... & Wilkins, C. (2022). Eight problems with literature reviews and how to fix them. *Nature Ecology & Evolution, 6*(1), 21–34.

Hagborg, J. M., Kalin, T., & Gerdner, A. (2022). The Childhood Trauma Questionnaire—Short

Form (CTQ-SF) used with adolescents – methodological report from clinical and community samples. *Journal of Child & Adolescent Trauma*, *15*(4), 1199–1213.

Harrer, M., Cuijpers, P., Furukawa, T. A., & Ebert, D. D. (2019). *Doing Meta-Analysis with R: A Hands-on Guide*. Chapman and Hall/CRC.

Hawton, K., Norris, T., Crawley, E., & Shield, J. P. H. (2018). Is child abuse associated with adolescent obesity? *Childhood Obesity*, *14*(2), 106–113.

Heim, C., Nater, U. M., Maloney, E., Boneva, R., Jones, J. F., & Reeves, W. C. (2009). Childhood trauma and risk for chronic fatigue syndrome: Association with neuroendocrine dysfunction. *Archives of General Psychiatry*, 66(1), 72-80.

Higgins, J. P. T., & Thompson, S. G. (2002). Quantifying heterogeneity in a meta-analysis. *Statistics in Medicine, 21*(11), 1539–1558.

Higgins, J. P. T., Thompson, S. G., Deeks, J. J., & Altman, D. G. (2003). Measuring inconsistency in meta-analyses. *BMJ, 327*(7414), 557–560.

Humphreys, K. L., LeMoult, J., Wear, J. G., Piersiak, H. A., Lee, A., & Gotlib, I. H. (2020). Child maltreatment and depression: A meta-analysis of studies using the Childhood Trauma Questionnaire. *Child Abuse & Neglect*, *102*, 104361.

IntHout, J., Ioannidis, J. P., Rovers, M. M., & Goeman, J. J. (2016). Plea for routinely presenting prediction intervals in meta-analysis. *BMJ open*, *6*(7), e010247.

Jackson, D. B., & Turner, R. J. (2017). The relationship between childhood maltreatment and obesity in adulthood: A systematic review. *Journal of Interpersonal Violence, 32*(19), 2943–2966.

Jones, A., Di Lemma, L. C., Robinson, E., Christiansen, P., Nolan, S., Tudur-Smith, C., & Field, M. (2016). Inhibitory control training for appetitive behaviour change: A meta-analytic investigation of mechanisms of action and moderators of effectiveness. *Appetite*, *97*, 16-28.

Jun, H. J., Corliss, H. L., Boynton-Jarrett, R., Spiegelman, D., Austin, S. B., & Wright, R. J. (2012). Growing up in a domestic violence environment: relationship with developmental trajectories of body mass index during adolescence into young adulthood. *Journal of Epidemiology and Community Health*, *66*(7), 629-635.

Kiddle, B., Inkster, B., Prabhu, G., Moutoussis, M., Whitaker, K. J., Bullmore, E. T., ... & Jones, P. B. (2018). Cohort profile: the NSPN 2400 Cohort: A developmental sample supporting the Wellcome Trust Neuroscience in Psychiatry Network. *International Journal of Epidemiology*, *47*(1), 18-19g.

Kennedy, A. K., Schneiderman, J. U., & Negriff, S. (2020). Body appreciation and body dissatisfaction between maltreated and comparison adolescents. *Children and Youth Services Review*, *108*, 104514.

Knutson, J. F., Taber, S. M., Murray, A. J., Valles, N. L., & Koeppl, G. (2010). The role of care neglect and supervisory neglect in childhood obesity in a disadvantaged sample. *Journal of Pediatric Psychology, 35*(5), 523-532.

Kulendran, M., Vlaev, I., Gamboa, P., & Darzi, A. (2017). The role of impulsivity in obesity as measured by inhibitory control: a systematic review. *Medical Research Archives*, *5*(8).

Lee, V., & Hoaken, P. N. (2007). Cognition, emotion, and neurobiological development: Mediating the relation between maltreatment and aggression. *Child Maltreatment*, *12*(3), 281-298.

Li, J. C., Hall, M. A., Shalev, I., Schreier, H. M., Zarzar, T. G., Marcovici, I., ... & Noll, J. G. (2021). Hypothalamic-pituitary-adrenal axis attenuation and obesity risk in sexually abused females. *Psychoneuroendocrinology*, *129*, 105254.

Lissau, I., & Sørensen, T. I. A. (1994). Seasonal variation in weight and overweight in a nationally representative sample of Danish young men. *International Journal of Obesity, 18*(11), 727–731.

Little, R. J. A. (1988). A Test of Missing Completely at Random for Multivariate Data with Missing Values. *Journal of the American Statistical Association*, *83*(404), 1198–1202.

Liu, R. T. (2019). Childhood maltreatment and impulsivity: A meta-analysis and recommendations for future study. *Journal of Abnormal Child Psychology*, *47*(2), 221-243.

Lo, C. C., & Cheng, T. C. (2007). The impact of childhood maltreatment on young adults' substance abuse. *The American Journal of Drug and Alcohol Abuse, 33*(1), 139-146.

Luppino, F. S., de Wit, L. M., Bouvy, P. F., Stijnen, T., Cuijpers, P., Penninx, B. W., & Zitman, F. G. (2010). Overweight, obesity, and depression: a systematic review and meta-analysis of longitudinal studies. *Archives of General Psychiatry*, *67*(3), 220-229.

Mamun, A. A., Lawlor, D. A., O'callaghan, M. J., Bor, W., Williams, G. M., & Najman, J. M. (2007). Does childhood sexual abuse predict young adult's BMI? A birth cohort study. *Obesity*, *15*(8), 2103-2110.

Marques, E. S., Hasselmann, M. H., de Barros Vianna, G. V., de Paula Mendonça, E., & Azeredo, C. M. (2022). Association between interpersonal violence with inadequate nutritional status among Brazilian adolescents. *Journal of Interpersonal Violence*, *37*(13-14), NP12066-NP12085.

McEwen, B. S., & Stellar, E. (1993). Stress and the individual mechanisms leading to disease. *Archives of Internal Medicine, 153*, 2093–2101.

Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & PRISMA Group. (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *PLOS Medicine, 6*(7), e1000097.

Muthén, L. K., & Muthén, B. O. (2002). How to Use a Monte Carlo study to decide on sample size and determine power. *Structural Equation Modeling: A Multidisciplinary Journal*, *9*(4), 599–620.

National Institute for Clinical Excellence. (2012). *Quality Appraisal Checklist for Studies Reporting Correlations and Associations*.

National Institute for Health and Care Excellence. (2014). *Obesity: Identification, assessment and management* (NICE Guideline No. CG189). https://www.nice.org.uk/guidance/cg189

Noll, J. G., Zeller, M. H., Trickett, P. K., & Putnam, F. W. (2007). Obesity risk for female victims of childhood sexual abuse: a prospective study. *Pediatrics*, *120*(1), e61-e67.

Noll, J. G. (2017). Sexual abuse and obesity in adolescence: A systematic review. *Journal of Adolescent Health, 60*(3), 273–283.

NHS Digital. (2023). *Health Survey for England 2022: Part 2*. Retrieved from https://digital.nhs.uk/data-and-information/publications/statistical/health-survey-for-england/2022-part-2

O'Neill, A., Beck, K., Chae, D., Dyer, T., He, X., & Lee, S. (2018). The pathway from childhood maltreatment to adulthood obesity: The role of mediation by adolescent depressive symptoms and BMI. *Journal of Adolescence*, *67*, 22–30.

Park, S. C., Kato, T. A., Lee, J. H., & Yu, S. H. (2025). Exploring the bidirectional relationship between depression and obesity. *Endocrinology and Metabolism Clinics*, *54*(1), 193-206.

Park, A., & Kim, Y. (2018). The longitudinal influence of child maltreatment on child obesity in South Korea: The mediating effects of low self-esteem and depressive symptoms. *Children and Youth Services Review*, *87*, 34-40.

Peckins, M. K., Negriff, S., Gordis, E. B., Zhen, A., & Susman, E. J. (2024). Maltreatment type differences in cortisol stress response trajectories across adolescence. *Child Development*, *95*(4), 1092-1108.

Perera, B., Østbye, T., Ariyananda, P. L., & Lelwala, E. (2009). Prevalence and correlates of physical and emotional abuse among late adolescents. *Ceylon Medical Journal*, *54*(1).

Peterson, R. A., & Brown, S. P. (2005). On the use of beta coefficients in meta-analysis. *Journal of Applied Psychology, 90*(1), 175–181.

Radford, L. (2011). *Child Abuse and Neglect in the UK Today*. NSPCC.

R Core Team. (2024). *R: A language and environment for statistical computing*. R Foundation

for Statistical Computing. https://www.R-project.org/

Richardson, L. P., Davis, R., Poulton, R., McCauley, E., Moffitt, T. E., Caspi, A., & Connell, F. (2003). A longitudinal evaluation of adolescent depression and adult obesity. *Archives of Pediatrics & Adolescent Medicine*, *157*(8), 739–745.

Sacks, R. M., Takemoto, E., Andrea, S., Dieckmann, N. F., Bauer, K. W., & Boone-Heinonen, J. (2017). Childhood maltreatment and BMI trajectory: The mediating role of depression. *American Journal of Preventive Medicine*, *53*(5), 625–633.

Schiff, M., Helton, J., & Fu, J. (2021). Adverse childhood experiences and obesity over time. *Public Health Nutrition*, *24*(11), 3205-3209.

Schneiderman, J. U., Mennen, F. E., Negriff, S., & Trickett, P. K. (2015). Overweight and obesity among maltreated youth placed in foster care. *Child Abuse & Neglect, 43*, 48–58.

Schroeder, K., Schuler, B. R., Kobulsky, J. M., & Sarwer, D. B. (2021). The association between adverse childhood experiences and childhood obesity: A systematic review. *Obesity Reviews*, *22*(7), e13204.

Schwarzer, G., Carpenter, J. R., & Rücker, G. (2015). *Meta-analysis with R*. Springer.

Soares, A. G., Zimmerman, A., Zammit, S., Karl, A., Halligan, S. L., & xFraser, A. (2021). Abuse in childhood and cardiometabolic health in early adulthood: Evidence from the Avon Longitudinal Study of Parents and Children. *Journal of the American Heart Association, 10*(24), e021701.

Sokol, R. L., Ennett, S. T., Shanahan, M. E., Gottfredson, N. C., Poti, J. M., Halpern, C. T., & Fisher, E. B. (2019). Maltreatment experience in childhood and average excess body

mass from adolescence to young adulthood. *Child Abuse & Neglect*, *96*, 104070.

Sterne, J. A. C., & Egger, M. (2001). Funnel plots for detecting bias in meta-analysis: Guidelines on choice of axis. *Journal of Clinical Epidemiology, 54*(10), 1046–1055.

Stewart, L., Moher, D., & Shekelle, P. (2012). Why prospective registration of systematic reviews makes sense. *Systematic Reviews*, *1*, 1-4.

Tewari, A., Kumar, G., Maheshwari, A., Tewari, V., & Tewari, J. (2023). Comparative evaluation of waist-to-height ratio and BMI in predicting adverse cardiovascular outcome in people with diabetes: A systematic review. *Cureus*, *15*(5).

Thabrew, H., Stasiak, K., Bavin, L., Frampton, C., & Merry, S. (2018). Validation of the Mood and Feelings Questionnaire (MFQ) and Short Mood and Feelings Questionnaire (SMFQ) in New Zealand help-seeking adolescents. *International Journal of Methods in Psychiatric Research*, *27*(3), e1610.

Tran, N. K., Van Berkel, S. R., van IJzendoorn, M. H., & Alink, L. R. (2017). The association between child maltreatment and emotional, cognitive, and physical health functioning in Vietnam. *BMC Public Health*, *17*, 1-13.

Tingley, D., Yamamoto, T., Hirose, K., Keele, L., & Imai, K. (2014). Mediation: R package for causal mediation analysis. *Journal of Statistical Software*, *59*, 1–38.

Vámosi, M., Heitmann, B. L., & Kyvik, K. O. (2010). The relation between an adverse psychological and social environment in childhood and the development of adult obesity: A systematic literature review. *Obesity Reviews*, *11*(3), 177–184.

Van Buuren, S., & Groothuis-Oudshoorn, K. (2011). mice: Multivariate imputation by chained

equations in R. *Journal of Statistical Software*, *45*, 1–67.

Von Elm, E., Altman, D. G., Egger, M., Pocock, S. J., Gøtzsche, P. C., & Vandenbroucke, J. P. (2007). The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: Guidelines for reporting observational studies. *PLoS Medicine, 4*(10), e296.

Wallace, C., & Krugman, R. (2024). More than what you eat: A Review on the Association Between Childhood Maltreatment and Elevated Adult BMI. *Current Nutrition Reports*, *13*(3), 377–381.

Wells, J. C. K., & Fewtrell, M. S. (2006). Measuring body composition. *Archives of Disease in Childhood*, *91*(7), 612–617.

Whitaker, R. C., Phillips, S. M., & Orzol, S. M. (2007). The association between maltreatment and obesity among preschool children. *Pediatrics, 120*(3), 540–546.

World Health Organization. (2024, November 5). *Child maltreatment*. https://www.who.int/news-room/fact-sheets/detail/child-maltreatment.

Zhang, H., Luo, Y., Davis, T., & Zhang, L. (2021). Interactive effects of childhood maltreatment and tonic respiratory sinus arrhythmia on young adults' depressive symptoms. *Psychophysiology*, *58*(10), e13900.

Appendix A:
Deviations from the protocols for systematic review and meta-analysis

During the course of this review, a few deviations from the original PROSPERO-registered protocol (CRD42024493363) were made based on practical considerations. While the plan was to explore a wider range of moderators—including age group, type of maltreatment, assessment method, study design, and country income level—we only included age group, study quality, study design, and publication year in the final moderation analysis. This was mainly because some categories were underreported or did not have enough studies for meaningful comparison. We also planned to assess publication bias using Egger's test and funnel plots, but these analyses weren't carried out, as there were fewer than ten studies in any given meta-analysis, which didn't meet the minimum requirement for these methods. Lastly, Holm-Bonferroni corrections were not applied as originally intended, since only a limited number of subgroup comparisons were conducted. These adjustments were made to align with the data available and to ensure the analyses remained appropriate and interpretable.

Appendix B:
Deviations from the protocols for empirical study

In the pre-registration, we planned to categorise weight status using BMI categories. However, after reviewing the distribution of the data and the variation in age across participants, we opted to use zBMI for adolescents and BMI for young adults. This change allowed for more age-appropriate and standardised comparisons, ensuring that the continuous nature of the weight variable was retained across the full sample.

We also initially proposed to examine the association between prefrontal cortical thickness/volume and weight outcomes, and to test whether this relationship was mediated by inhibitory control. Due to scope and data availability constraints within the current project timeline, the neuroimaging data were not included in this thesis. Instead, we focused on inhibitory control and depressive symptoms as potential mediators of the association between childhood trauma and weight outcomes. The planned analysis involving cortical thickness remains part of the broader research proposal and will be pursued in a future follow-up study.

Appendix C:
Author Guidelines for International Journal of Obesity (IJO)

Article: An Article is a substantial, in-depth, novel research study of interest to the readership of the journal. The structure an Article should follow is detailed below.
Specifications: Structured abstract max. 300 words; Main body of text (excluding abstract, tables/figures, and references) not to exceed 4,000 words; Max 6 tables or figures (Note: composite figures containing more than three individual figures will count as two figures); Max 60 references

Review Article:
A Review Article is an authoritative, balanced survey of recent developments in a research field. Review Articles should incorporate a) a review of previously published literature from the past 5-10 years, describing the pros and cons of these studies, b) the authors opinion on how to approach the issue/situation being discussed, c) the authors thoughts on what is necessary to move the field forward in the future.
PLEASE NOTE: All reviews should include search criteria and selection criteria in a Methods Section, along with the total number of articles identified and the total number selected for inclusion in the review.
Specifications: Unstructured abstract max. 300 words; Main body of text (excluding abstract, tables/figures, and references) not to exceed 6,000 words; Max 8 tables or figures (Note: composite figures containing more than three individual figures will count as two figures); Max 120 references

Systematic Review Article (with or without Meta-Analysis):
A systematic review is a comprehensive high-level summary of primary research on a clearly formulated topic. Systematic reviews aim to use systematic, reproducible, and explicit methods to first identify, select, and critically appraise (including identification of bias) primary research, and to next extract, analyze, and summarize data from the studies that are included in the review. Systematic reviews may include meta-analysis, which additionally utilizes statistical methods to quantitatively evaluate pooled data from single studies. Individual studies are assigned a weight based on the sample size. Conclusions are reported based on the accuracy and precision of individual studies' results.
Specifications: Structured abstract max. 300 words; Main body of text (excluding abstract, tables/figures, and references) not to exceed 6,000 words; Max 8 tables or figures (Note: composite figures containing more than three individual figures will count as two figures); Max 120 references

Clinical Trials

The *International Journal of Obesity* is interested in attracting the submission of manuscripts describing new therapeutic approaches to obesity treatment. These human intervention trials of new therapies can be pharmacological, surgical, dietary, physical activity, nutraceutical (including herbal preparations), behavioural or some other relevant intervention, but must be novel, include an appropriate control group and be of a sufficiently long duration to generate results of clinical relevance. Trials which also consider maintenance of weight loss would be of particular interest. With regard to the duration of such trials, the following will apply:

1. Diet/lifestyle/nutraceutical interventions. The total duration (weight loss plus weight maintenance) should usually be at least 1 year. Anything less than this is of little practical value and is highly unlikely to reveal any novel mechanistic findings. The only exception would be if a shorter period of intervention was accompanied by a truly novel mechanistic approach. Even then the study should be at least 3 months in duration and such papers normally would be submitted as Short Communications.
2. Surgery Short term, post-surgery studies are of minimal value as many are likely to be in the rapid phase of weight loss and unlikely to achieve a state of weight maintenance. Thus, we encourage surgical studies of 1 year or more in duration and linked with novel mechanistic/physiological measurements. The only exceptions would be if a shorter period of intervention were accompanied by a truly novel mechanistic approach and such papers normally would be submitted as Short Communications.
3. Drug studies 1 year or longer studies with truly novel agents are unrealistic. However, a 3 month study with a truly novel agent would not normally deserve to be published as a full paper and should be submitted as a Short Communication if it is of less than 1 year duration. Any established drug being applied to obesity (e.g. the application of anti-depressants to an obesity target) or any obesity drug which has already produced publications demonstrating efficacy in humans should be studied for at least 1 year.

In addition to these trials of new therapeutic approaches, the *International Journal of Obesity* is also interested in publishing systematic reviews of weight loss and weight maintenance interventions in human subjects. However, these reviews and any associated meta-analyses should usually be concerned with studies that are of a duration of at least 6 months and preferably 1 year. See our Editorial Policy section for further information.

Technical Report: Technical Reports are articles that address areas of more methodological interest. The contents of these Reports must have the same level of scientific rigour expected of an Article.
Specifications: Structured abstract max. 300 words; Main body of text (excluding abstract, tables/figures, and references) not to exceed 2,500 words; Max 4 tables or figures (Note: composite figures containing more than three individual figures will count as two figures); Max 25 references

Correspondence: Correspondence provides readers with a forum for comment on papers published in a previous issue of the journal. Correspondences must reference the original source but can use an arbitrary title.
Specifications: No abstract required; Main body of text (excluding tables/figures, and references) not to exceed 500 words; Max 2 tables or figures (Note: composite figures containing more than three individual figures will count as two figures); Max 10 references

Brief Communication: These are studies that fall short of the criteria for full Articles (e.g. preliminary experiments limited by sample size or duration, or novel hypotheses). Apart from including an abstract, there is no obligation to divide the text into sections
Specifications: Unstructured abstract max. 200 words; Main body of text (excluding tables/figures, and references) not to exceed 1,500 words; Max 2 tables or figures (Note: composite figures containing more than three individual figures will count as two figures); Max 20 references

Perspective: A Perspective is intended to provide a forum for authors to discuss models and ideas from a personal viewpoint. They are more forward looking and/or speculative than Review Articles and may take a broader field of view. These are mainly opinions, but should be grounded in science and available data. These can be new interpretations or thoughtful synthesis and presentations of available information and concepts. An essential feature of a Perspective would be to present a novel/fresh/creative way of interpreting or explaining various aspects of obesity. It is intended that these brief writings will initiate discourse and will contribute to conceptually advancing the field of obesity.
Perspectives are regularly commissioned, however pre-submission enquiries are also welcome. Please contact the editorial office (ijo@nature.com) to propose an idea.
Specifications: No abstract required; Main body of text (excluding tables/figures, and references) not to exceed 1,000 words; Max 2 tables or figures; Max 10 references

Editorial (by Editor invitation only): If you wish to offer an unsolicited contribution, we ask you to first contact the editorial office with your request.
Specifications: No abstract required; Main body of text (excluding tables/figures, and references) not to exceed 1,000 words; Max 2 tables or figures (Note: composite figures containing more than three individual figures will count as two figures); Max 10 references

Comment: Comments discuss issues of particular significance to the field, or highlight significant papers, in *IJO* or elsewhere.
Specifications: No abstrcat required; Main body of text (excluding tables/figures, and references) not to exceed 750 words; Max 2 tables or figures (Note: composite figures containing more than three individual figures will count as two figures); Max 10 references

Due to the high volume of submissions that the *Journal* receives, the following manuscripts will be deemed low priority:

- Simple prevalence studies involving a single country at a single time-point.
- Studies that merely confirm established facts from previous publications and that contain little new information. For example, it is hard to justify publication space for studies that report obesity is associated with known health risks. Therefore, studies that replicate the findings of previously published papers will tend to have a lower priority. If similar data are already published, it will be critical for authors to explain the novelty of their manuscript in the covering letter to the editor
- Those that involve co-morbidities of obesity (e.g. diabetes, cardiovascular disease), without having obesity-specific components to them. Recent examples include manuscripts that look at associations between inflammatory markers and diabetes or cardiovascular disease. This information is clearly of medical relevance, but is not necessarily a high priority for a journal devoted to obesity research.
- Those that report the absence of links between obesity and a specific genotype or polymorphism; it is possible that such a work could be considered in the form of a Short Communication, but a full manuscript is not justified.
- Those that describe anthropometric indices of obesity that might correlate with plasma markers of co-morbidities, but do not include any data relating to outcome of the co-morbidities.
- Retrospective studies, secondary analyses of data that arise from studies that were not primary concerned with obesity or body weight, or clinical “audits” (for example of surgical interventions) that were not designed as appropriately controlled clinical research interventions, unless there is particularly novel information presented that is of importance to the medical literature.
- Those that claim to be pediatric articles but which do not deal specifically with children and adolescents up to the age of 18 years.
- Case reports that do not describe a critical finding or major addition to the literature.
- Clinical trials less than one year in duration – see further details below.

If authors wish to submit articles to the *International Journal of Obesity* in the above areas, they would need to state clearly in the covering letter and introduction to the manuscript what is novel and informative about the study and why it is a valuable addition to the scientific literature.

Preparation of Articles

House Style: Authors should adhere to the following formatting guidelines

- Text should be double spaced with a wide margin.
- All pages and lines are to be numbered.

- Do not make rules thinner than 1pt (0.36mm).
- Use a coarse hatching pattern rather than shading for tints in graphs.
- Colour should be distinct when being used as an identifying tool.
- Spaces, not commas should be used to separate thousands.
- At first mention of a manufacturer, the town (and state if USA) and country should be provided.
- *Statistical methods*: For normally distributed data, mean (SD) is the preferred summary statistic. Relative risks should be expressed as odds ratios with 95% confidence interval. To compare two methods for measuring a variable the method of Bland & Altman (1986, Lancet 1, 307–310) should be used; for this, calculation of P only is not appropriate.
- *Units***:** Use metric units (SI units) as fully as possible. Preferably give measurements of energy in kiloJoules or MegaJoules with kilocalories in parentheses (1 kcal = 4.186kJ). Use % throughout.
- *Abbreviations*: On first using an abbreviation place it in parentheses after the full item. Very common abbreviations such as FFA, RNA, need not be defined. Note these abbreviations: gram g; litre l; milligram mg; kilogram kg; kilojoule kJ; megajoule MJ; weight wt; seconds s; minutes min; hours h. Do not add ‘s’ for plural units. Terms used less than four times should not be abbreviated.
- *People first or Person first language (PFL):* The *International Journal of Obesity* requires its authors to use people first language in all articles published in the journal. Thus, we expect authors to use terms such as 'people with obesity’ or ‘people with overweight' instead of ‘obese people’, or ‘overweight people’ in all manuscripts submitted to the journal. The terms ‘obese’, ‘morbidly obese’ and ‘morbid obesity’ should not be used. This applies to both animal studies and human studies. This also applies when referring to other medical conditions e.g., ‘people with diabetes’ should be used rather than ‘diabetic people’. Submissions which do not conform to the outlined requirements will be returned to authors and will not be considered for publication unless the appropriate amendments are made.
- *Sex vs. Gender:* There is a need to clarify the use of “gender” vs “sex” in manuscripts. “Gender” is a self-identified term whereas “sex” is determined at birth by the presence or absence of a Y chromosome. For biological studies, “sex” is the term that should be used in the *International Journal of Obesity*. "Gender" may be used in manuscripts in which the participants have been asked to state their self-ascribed gender. We would expect all pediatric studies to use the term sex, because the questionnaires which are typically used for children use the word "sex" and list only M/F. In addition, BMI charts are based on biological sex. For adult studies, in which the participants have greater agency in self-ascribing gender, which term is used depends on how sex or gender was determined in the study. For example, if a survey is given to research participants asking how they categorize their own gender, then it should be stated throughout that the variable was "self-reported gender". By contrast if they were simply asked whether they were Male or Female then it should be reported as sex.

Cover Letter: Authors should provide a cover letter that includes the affiliation and contact information for the corresponding author. Authors should briefly discuss the importance of the work and explain why it is considered appropriate for the diverse readership of the journal. The cover letter should confirm the material is original research, has not been previously published and has not been submitted for publication elsewhere while under consideration. If the manuscript has been previously considered for publication in another journal, please include the previous reviewer comments, to help expedite the decision by the Editorial team.

Title Page: The title page should contain:

- Title of the paper - brief, informative, of 150 characters or less and should not make a statement or conclusion. Should have no mention of tradenames/products.
- Full names of all the authors and their affiliations, together with the name, full postal address, telephone number and e-mail address of the corresponding author. If authors regard it as essential to indicate that two or more co-authors are equal in status, they may be identified by an asterisk symbol with the caption 'These authors contributed equally to this work' immediately under the address list.
- Competing Interests statement (see Editorial Policies section). Authors should disclose the sources of any support for the work received in the form of grants and/or equipment and drugs.

Large Language Models (LLMs), such as ChatGPT, do not currently satisfy our authorship criteria. Notably an attribution of authorship carries with it accountability for the work, which cannot be effectively applied to LLMs. Use of an LLM should be properly documented in the Methods section (and if a Methods section is not available, in a suitable alternative part) of the manuscript.

Abstract: Articles must be prepared with a structured abstract designed to summarise the essential features of the paper in a logical and concise sequence under the following headings:

- Background/Objectives: What was the main question or hypothesis tested?
- Subjects/Methods: How many subjects were recruited, how many dropped out? Was the study randomised, case-controlled etc?
- Interventions/methods used and duration of administration.
- Results: Indicate 95% confidence intervals and exact P value for effects.
- Conclusions: Answer (significant or not) to main question.

Graphical Abstracts (optional): A graphical abstract, which summarizes the manuscript in a visual way, is designed to attract the attention of readers in the table of contents of the journal. Files should be uploaded as a 'Figure' and be labelled 'Graphical abstract'. A standard file format (.tiff, .eps, .jpg, .bmp, .doc, or .pdf.) should be used, and the graphic should be 9 cm

wide x 5 cm high when printed at full scale and a minimum of 300 dpi. All graphical abstracts should be submitted with a white background and imagery should fill the available width, whenever possible. Colour graphical abstracts are encouraged and will be published at no additional charge. Textual statements should be kept to a minimum.

Introduction: The Introduction should assume that the reader is knowledgeable in the field and should therefore be as brief as possible but can include a short historical review where desirable.

Materials/Subjects and Methods: This section should contain sufficient detail, so that all experimental procedures can be reproduced, and include references. Methods, however, that have been published in detail elsewhere should not be described in detail. Authors should provide the name of the manufacturer and their location for any specifically named medical equipment and instruments, and all drugs should be identified by their pharmaceutical names, and by their trade name if relevant.

Results: The Results section should briefly present the experimental data in text, tables or figures. Tables and figures should not be described extensively in the text.

Discussion: The Discussion should focus on the interpretation and the significance of the findings with concise objective comments that describe their relation to other work in the area. It should not repeat information in the results. The final paragraph should highlight the main conclusion(s), and provide some indication of the direction future research should take.

Acknowledgements: These should be brief, and should include sources of support including sponsorship (e.g. university, charity, commercial organisation) and sources of material (e.g. novel drugs) not available commercially.

Author Contributions: Authors must include a statement about the contribution of each author to the manuscript (see Editorial Policies page for details regarding authorship). The statement can be up to several sentences long, describing the tasks of individual authors referred to by their initials.
See example below:
MAJ was responsible for designing the review protocol, writing the protocol and report, conducting the search, screening potentially eligible studies, extracting and analysing data, interpreting results, updating reference lists and creating 'Summary of findings' tables. SBM was responsible for designing the review protocol and screening potentially eligible studies. She contributed to writing the report, extracting and analysing data, interpreting results and creating 'Summary of findings' tables. DIH conducted the meta-regression analyses and contributed to the design of the review protocol, writing the report, arbitrating potentially

eligible studies, extracting and analysing data and interpreting results. NAL contributed to data extraction and provided feedback on the report. FRT and RAL provided feedback on the report.

Competing Interests: Authors must declare whether or not there are any competing financial interests in relation to the work described. This information must be included at this stage and will be published as part of the paper, but should also be noted on the title page. Please see the Competing Interests definition in the Editorial Policies section for detailed information.

Data Availability Statement: An inherent principle of publication is that others should be able to replicate and build upon the authors' published claims. *International Journal of Obesity* adheres to Springer Nature's Data Policy Type 3. This means that a submission to the journal implies that materials described in the manuscript, including all relevant raw data, will be freely available to any researcher wishing to use them for non-commercial purposes, without breaching participant confidentiality. It also means that a Data Availability Statement (see here for more details) must be included as part of your manuscript.

References: Only papers directly related to the article should be cited. Exhaustive lists should be avoided. References should follow the Vancouver format. In the text they should appear as numbers starting at one and at the end of the paper they should be listed (double-spaced) in numerical order corresponding to the order of citation in the text. Where a reference is to appear next to a number in the text, for example following an equation, chemical formula or biological acronym, citations should be written as (ref. X). Example "detectable levels of endogenous Bcl-2 (ref. 3), as confirmed by western blot".
All authors should be listed for papers with up to six authors; for papers with more than six authors, the first six only should be listed, followed by *et al.* Abbreviations for titles of medical periodicals should conform to those used in the latest edition of Index Medicus. The first and last page numbers for each reference should be provided. Abstracts and letters must be identified as such. Papers in press may be included in the list of references.
Personal communications can be allocated a number and included in the list of references in the usual way or simply referred to in the text; the authors may choose which method to use. In either case authors must obtain permission from the individual concerned to quote his/her unpublished work.

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Journal article: Neidlein, S, Wirth, R, Pourhassan, M. Iron deficiency, fatigue and muscle strength and function in older hospitalized patients. Eur J Clin Nutr. 2020; 75:456–463.
Journal article by DOI: Kurotani K, Shinsugi C, Takimoto H. Diet quality and household income level among students: 2014 National Health and Nutrition Survey Japan. Eur J Clin Nutr. 2020; https://doi.org/10.1038/s41430-020-00794-1.
Journal article, in press: Gallardo RL, Juneja HS, Gardner FH. Normal human marrow stromal cells induce clonal growth of human malignant T-lymphoblasts. Int. J Cell Cloning (in press).

Complete book: Atkinson K, Champlin R, Ritz J, Fibbe W, Ljungman P, Brenner MK (eds). Clinical Bone Marrow and Blood Stem Cell Transplantation. 3rd ed. Cambridge University Press, Cambridge, 2004.
Chapter in book: Coccia PF. Hematopoietic cell transplantation for osteopetrosis. In: Blume KG, Forman SJ, Appelbaum FR (eds). Thomas' Hematopoietic Cell Transplantation. 3rd ed. Blackwell Publishing Ltd, Malden, 2004. pp 1443–1454.
Abstract: Abstracts from the 2020 Annual Scientific Meeting of the British and Irish Hypertension Society (BIHS). J Hum Hypertens 34; 2020; 1–20
Website: Kassambara A. rstatix: pipe-friendly framework for basic statistical tests. 2020. https://rpkgs.datanovia.com/rstatix/.
Online Document: Doe J. Title of subordinate document. In: The dictionary of substances and their effects. Royal Society of Chemistry. 1999. http://www.rsc.org/dose/title of subordinate document. Accessed 15 Jan 1999.

Tables: Tables should only be used to present essential data; they should not duplicate what is written in the text. All tables must be editable, ideally presented in Excel. Each must be uploaded as a separate workbook with a title or caption and be clearly labelled, sequentially. Please make sure each table is cited within the text and in the correct order, e.g. (Table 3). Please save the files with extensions .xls / .xlsx / .ods / or .doc or .docx. Please ensure that you provide a 'flat' file, with single values in each cell with no macros or links to other workbooks or worksheets and no calculations or functions.

Figure Legends: These should be brief, specific and appear on a separate manuscript page after the References section.

Figures: Figures and images should be labelled sequentially and cited in the text. Figures should not be embedded within the text but rather uploaded as separate files. The use of three-dimensional histograms is strongly discouraged unless the addition of the third dimension is important for conveying the results. Composite figures containing more than three individual figures will count as two figures. All parts of a figure should be grouped together. Where possible large figures and tables should be included as supplementary material.
Detailed guidelines for submitting artwork can be found by downloading our Artwork Guidelines. Using the guidelines, please submit production quality artwork with your initial online submission. If you have followed the guidelines, we will not require the artwork to be resubmitted following the peer-review process, if your paper is accepted for publication.

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Graphs, Histograms and Statistics
Plotting individual data points is preferred to just showing means, especially where N<10
If error bars are shown, they must be described in the figure legend
Axes on graphs should extend to zero, except for log axes
Statistical analyses (including error bars and p values) should only be shown for independently repeated experiments, and must not be shown for replicates of a single experiment
The number of times an experiment was repeated (N) must be stated in the legend

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Please submit supplementary figures, small tables and text as a single combined PDF document. Tables longer than one page should be provided as an Excel or similar file type. Please refer to the journal's Data Policies, outlined in the Editorial Policies section of these guidelines for additional options for such files, and which provides guidance on alternatives to supplementary files for data deposition, linking, preservation, and storage.

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- Include a text summary (no more than 50 words) to describe the contents of each file.
- Identify the types of files (file formats) submitted.

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Please take note of the technical requirements listed below.
Technical requirements:
The maximum file size of a video should not exceed 25 GB. An audio track is required, and video and audio streams must be in the correct order (video before audio). To ensure streamed video playout in HD in an acceptable quality, the following minimum requirements are recommended:
Resolution - At least 480p. If no HD is available: 1024 x 576 (PAL 16:9) respectively 768 x 576 (PAL 4:3)
Aspect ratio - Standard 16:9 or acceptable 4:3
Video bitrate - 5.000 to 10.000 Kbit/s
Audio bitrate - 320 Kbit/s, stereo, 44,1 KHz
Sound - AAC

Tips for presentation:
1. The video should introduce the topic of the article, highlight the main results and conclusions, discuss the current status and potential future developments in the field
2. Write your script and practise first – explain any obscure terminology
3. Film in a quiet room against a plain (white if possible) background and ensure there is nothing confidential in view
4. Avoid using background music
5. Include figures, slides, video clips of the experiment, etc. to help explain your methods and results. Please try to include a mixture of you talking to the camera and slides – it is nice for viewers to see your face at times
6. Keep figures simple; don't show raw data and ensure any text is legible. Do not include lots of small text or data that won't be legible in a small video player that's the size of a smartphone screen.
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Files will be viewed by the editorial office for quality; however the onus for creating, uploading and editing the video falls on the author.

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Upon submission authors will be asked to select a series of subject terms relevant to the topic of their manuscript from our subject ontology. Providing these terms will ensure your article is more discoverable and will appear on appropriate subject specific pages on nature.com, in addition to the journal's own pages. Your article should be indexed with at least one, and up to four unique subject terms that describe the key subjects and concepts in your manuscript. Click here for help with this.

Appendix D:
Author Guidelines for Journal of Affective Disorders

About the journal
Aims and scope

Official Journal of the International Society for Affective Disorders *The Journal of Affective Disorders* publishes papers concerned with affective disorders in the widest sense: depression, mania, mood spectrum, emotions and personality, anxiety and stress. It is interdisciplinary and aims to bring together different approaches for a diverse readership. Top quality papers will be accepted dealing with any aspect of affective disorders, including neuroimaging, cognitive neurosciences, genetics, molecular biology, experimental and clinical neurosciences, pharmacology, neuroimmunoendocrinology, intervention and treatment trials.

Journal of Affective Disorders is the companion title to the open access Journal of Affective Disorders Reports.

Article types

The Journal primarily publishes:

Full-Length Research Papers

(up to 5000 words, excluding references and up to 6 tables/figures)

Review Articles and Meta-analyses

(up to 8000 words, excluding references and up to 10 tables/figures)

Short Communications

(up to 2000 words, 20 references, 2 tables/figures)

Correspondence

(up to 1000 words, 10 references, 1 table/figure).

At the discretion of the accepting Editor-in-Chief, and/or based on reviewer feedback, authors may be allowed fewer or more than these guidelines.

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This journal follows a single anonymized review process. Your submission will initially be assessed by our editors to determine suitability for publication in this journal. If your submission is deemed suitable, it will typically be sent to a minimum of two reviewers for an independent expert assessment of the scientific quality. The decision as to whether your article

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Authorship

All authors should have made substantial contributions to all of the following:

The conception and design of the study, or acquisition of data, or analysis and interpretation of data.

Drafting the article or revising it critically for important intellectual content.

Final approval of the version to be submitted.

Authors should appoint a corresponding author to communicate with the journal during the editorial process. All authors should agree to be accountable for all aspects of the work to ensure that the questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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Any addition, deletion or rearrangement of author names in the authorship list should only be made prior to acceptance, and only if approved by the journal editor.

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Funding: This work was supported by the National Institutes of Health [grant numbers xxxx, yyyy]; the Bill & Melinda Gates Foundation, Seattle, WA [grant number zzzz]; and the United States Institutes of Peace [grant number aaaa].

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gender

race

ethnicity

culture

sexual orientation

disability or health condition

We recommend avoiding the use of descriptors about personal attributes unless they are relevant and valid. Write for gender neutrality with the use of plural nouns ("clinicians, patients/clients") as default. Wherever possible, avoid using "he, she," or "he/she."

No assumptions should be made about the beliefs of readers and writing should be free from bias, stereotypes, slang, reference to dominant culture and/or cultural assumptions.

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There is no single, universally agreed-upon set of guidelines for defining sex and gender. We offer the following guidance:

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Sex and/or gender dimensions of the research should be addressed within the article or declared as a limitation to the generalizability of the research.

Definitions of sex and/or gender applied should be explicitly stated to enhance the precision, rigor and reproducibility of the research and to avoid ambiguity or conflation of terms and the constructs to which they refer.

We advise you to read the Sex and Gender Equity in Research (SAGER) guidelines and the SAGER checklist (PDF) on the EASE website, which offer systematic approaches to the use of sex and gender information in study design, data analysis, outcome reporting and research interpretation.

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Definitions of sex and/or gender

We ask authors to define how sex and gender have been used in their research and publication. Some guidance:

Sex generally refers to a set of biological attributes that are associated with physical and physiological features such as chromosomal genotype, hormonal levels, internal and external anatomy. A binary sex categorization (male/female) is usually designated at birth ("sex assigned at birth") and is in most cases based solely on the visible external anatomy of a newborn. In reality, sex categorizations include people who are intersex/have differences of sex development (DSD).

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We ask you to provide editable source files for your entire submission (including figures, tables and text graphics). Some guidelines:

Save files in an editable format, using the extension .doc/.docx for Word files and .tex for LaTeX files. A PDF is not an acceptable source file.

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Remove any strikethrough and underlined text from your manuscript, unless it has scientific significance related to your article.

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Affiliations. Add affiliation addresses, referring to where the work was carried out, below the author names. Indicate affiliations using a lower-case superscript letter immediately after the author's name and in front of the corresponding address. Ensure that you provide the full postal address of each affiliation, including the country name and, if available, the email address of each author.

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Abstract

You are required to provide a concise and factual abstract which does not exceed 250 words. The abstract should briefly state the purpose of your research, principal results and major conclusions. Some guidelines:

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Avoid non-standard or uncommon abbreviations. If any are essential to include, ensure they are defined within your abstract at first mention.

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You are required to provide 1 to 7 keywords for indexing purposes. Keywords should be written in English. Please try to avoid keywords consisting of multiple words (using "and" or "of").

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Highlights

You are required to provide article highlights at submission.

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Present variables in italics.

Denote powers of e by exp.

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Tables must be submitted as editable text, not as images. Some guidelines:

Place tables next to the relevant text or on a separate page(s) at the end of your article.

Cite all tables in the manuscript text.

Number tables consecutively according to their appearance in the text.

Please provide captions along with the tables.

Place any table notes below the table body.

Avoid vertical rules and shading within table cells.

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Strunk Jr., W., White, E.B., 2000. The Elements of Style, fourth ed. Longman, New York.

Reference to a chapter in a book:

Mettam, G.R., Adams, L.B., 2023. How to prepare an electronic version of your article, in: Jones, B.S., Smith, R.Z. (Eds.), Introduction to the Electronic Age. E-Publishing Inc., New York, pp. 281–304.

Reference to a website:

Cancer Research UK, 2023. Cancer statistics reports for the UK. http://www.cancerresearchuk.org/aboutcancer/statistics/cancerstatsreport/ (accessed 13 March 2023).

Reference to a dataset:

Oguro, M., Imahiro, S., Saito, S., Nakashizuka, T., 2015. Mortality data for Japanese oak wilt disease and surrounding forest compositions [dataset]. Mendeley Data, v1. https://doi-org.uea.idm.oclc.org/10.17632/xwj98nb39r.1.

Reference to software:

Coon, E., Berndt, M., Jan, A., Svyatsky, D., Atchley, A., Kikinzon, E., Harp, D., Manzini, G., Shelef, E., Lipnikov, K., Garimella, R., Xu, C., Moulton, D., Karra, S., Painter, S., Jafarov, E., & Molins, S., 2020. Advanced Terrestrial Simulator (ATS) v0.88 (Version 0.88) [software]. Zenodo. https://doi-org.uea.idm.oclc.org/10.5281/zenodo.3727209.

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