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Abuse in childhood and cardiometabolic health in early adulthood: evidence from the Avon Longitudinal Study of Parents and Children

Soares. Childhood abuse and cardiometabolic health

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Abstract

Background: Although childhood abuse has been consistently associated with cardiovascular disease in later adulthood, its associations with cardiometabolic health in younger adults are poorly understood. We assessed associations between childhood physical, sexual, and psychological abuse and cardiometabolic outcomes at 18 and 25 years.

Methods and Results: We used data on 3,223 participants of the Avon Longitudinal Study of Parents and Children (ALSPAC). Exposure to childhood abuse was self-reported retrospectively at 22 years. We used linear regression to assess the associations between childhood abuse and cardiometabolic outcomes at 18 and 25 years. At 18 years, physical (β 1.35kg/m^2, 95%CI 0.66, 2.05), sexual (β 0.57kg/m^2, 95%CI 0.04, 1.11) and psychological (β 0.47kg/m^2, 95%CI 0.01, 0.92) abuse were associated with higher BMI. Physical abuse was also associated with lower HDL (β -0.07mmol/L, 95%CI -0.13, -0.01) and higher CRP (31%, 95%CI 1%, 69%), and sexual abuse was associated with higher heart rate (β 1.92bpm, 95%CI 0.26, 3.58). At age 25 all three types of abuse were additionally associated with higher insulin, and sexual abuse was associated with lower cholesterol (-0.14mmol/L, 95%CI -0.26, -0.01). The age at which abuse occurred (<11y/11-17y) had little influence on the associations, and when sex differences were evident, associations were stronger in males.

Conclusions: Childhood abuse is associated with negative cardiometabolic outcomes even by young adulthood. Further follow-up will determine whether associations strengthen across the life course and whether sex differences persist, which is essential for targeting effective screening programs and early interventions in those who suffered abuse in childhood.

Keywords: Cardiometabolic health, childhood abuse, ALSPAC

INTRODUCTION

A growing body of evidence demonstrates associations of childhood abuse with a wide range of adverse mental and physical health outcomes,[1, 2] including poorer cardiometabolic health. A recent review found that childhood abuse was associated with cardiovascular disease (CVD), diabetes and higher blood pressure/hypertension in the majority of studies.[3] However, the age at which associations between childhood abuse and poor cardiometabolic health emerge is unclear. Most studies explore the association of childhood abuse with cardiometabolic health later in adulthood. Those that have investigated cardiometabolic outcomes in younger age groups have found inconsistent results.[4-9] A systematic review reported a strong association between childhood maltreatment and obesity in adults, but this was not apparent in children and adolescents.[10] Longitudinal studies assessing body mass index (BMI) trajectories show that associations with childhood abuse vary by age and type of abuse, and positive associations emerge later in adulthood.[11] Understanding the age at which associations arise are essential for prevention efforts.

Women experience a greater burden of sexual abuse, whereas physical abuse is more common in men.[2] Sex differences in cardiometabolic health also exist, which might be driven by sex hormones, sex-specific molecular mechanisms, including glucose and lipid metabolism, as well as cardiac energy metabolism and cardiac function.[12] Sex differences in the associations between childhood abuse and cardiometabolic health are therefore plausible but evidence is limited, and among the studies that have explored sex differences, no consistent pattern has been found.[2, 3]

Many studies examine a broad range of adversities under the Adverse Childhood Experiences (ACEs) umbrella,[2, 13] which can include highly heterogeneous exposures (e.g. childhood abuse, neglect and several forms of household dysfunction), often combined into a summary score.[14] But there is limited understanding of how childhood abuse specifically impacts cardiometabolic health. Furthermore, most studies fail to consider the frequency and/or timing of the abuse.

We aimed to assess the associations of physical, sexual and psychological abuse in childhood with measures of cardiometabolic health in early adulthood (18 years and 25 years) in a contemporary general population cohort, explore whether there are sex differences in these associations, and whether associations differ by the age at which childhood abuse occurred.

METHODS

Data availability

Because of the sensitive nature of the data collected for this study, requests to access the dataset from qualified researchers may be sent to the ALSPAC Executive Committee at https://proposals.epi.bristol.ac.uk/.

Study Population

The Avon Longitudinal Study of Parents and Children (ALSPAC) is a prospective population-based pregnancy cohort (see www.alspac.bris.ac.uk) that recruited pregnant women living in the Avon area of the United Kingdom who were due to give birth between April 1991 and December 1992.[15] In total, 14,541 pregnancies were enrolled and children, mothers and their partners have been followed up repeatedly ever since. Please note that the study website contains details of all the data that is available through a fully searchable data dictionary and variable search tool. For full details of the data from the ALSPAC study, see http://www.bristol.ac.uk/alspac/researchers/our-data.

The study participant flow is given in Figure 1. Participants were included if they had data on at least one type of abuse and one cardiometabolic outcome. Participants pregnant at the 18- and 25-year clinic assessments were excluded as pregnancy could alter BMI and cardiometabolic health outcomes, resulting in the inclusion of 3,223 participants in the study. Ethical approval was obtained from the ALSPAC Law and Ethics Committee and the Local Research Ethics Committee. Consent for biological samples has been collected in accordance with the Human Tissue Act (2004).

Abuse in Childhood

Exposure to childhood abuse (before 18 years) was retrospectively self-reported in a questionnaire at ~22 years. The questionnaire used to collect information on abuse was based on the Child Abuse Questionnaire[16] and the Sexual Experiences Survey[17] and includes the three main types of abuse: physical, sexual and psychological abuse; see http://www.bristol.ac.uk/media-library/sites/alspac/documents/questionnaires/YPB-life-at-22-plus.pdf, section H. Participants were asked about experiences occurring in childhood (before 11 years), and during adolescence (11-17 years). Details about the abuse categorisation are available in supplementary material. We assessed abuse in each time period (<11/11-17 years) and also combined both time periods to indicate abuse <18 years, and generated a summary score varying from 0 (no experience of abuse <18 years old) to 3 (experience of all abuse types < 18 years old).

The study data were collected and managed using REDCap electronic data capture tools hosted at University of Bristol.[18]

Outcomes

Height and weight were measured in research clinics at both 18 and 25 years using standard procedures. Participants fasted overnight or for a minimum of 6 hours. Total cholesterol, plasma triglycerides and high-density lipoprotein (HDL) cholesterol were measured using enzymatic reagents for lipid determination from the standard Lipid Research Clinics Protocol. Low-density lipoprotein (LDL) cholesterol concentrations were calculated using the Friedewald equation.[19] Serum insulin was measured with ELISA (Mercodia, Uppsala, Sweden), which does not cross-react with proinsulin. An automated particle-enhanced immunoturbidimetric assay (Roche UK, Welwyn Garden City, UK) was used to measure plasma glucose and C-reactive protein (CRP).

Confounders

We considered household occupational social class, maternal and paternal education, ethnicity, age, and sex as potential confounders. Household occupational social class was assessed at recruitment to the study and defined based on the highest of mothers and their partners' self-reported occupation using the 1991 British Office of Population and Census Statistics (OPCS) classification. Maternal and paternal education were also assessed at recruitment and correspond to the highest educational attainment achieved. Ethnicity was classified as white/non-white, as most participants were of white ethnicity (96%).

Statistical Analysis

Data were analysed using Stata 16.1 (Stata Corp., 2016). Positively skewed outcome variables were log-transformed for analyses and back transformed for presentation of results.

We investigated each type of abuse separately and assessed associations of childhood abuse with cardiometabolic health considering abuse exposure occurring i. before 11 years, ii. between 11-17 years, and iii. at any age before 18 years. We used linear regression to estimate associations of childhood abuse with measures of cardiometabolic health at 18 and 25 years, unadjusted and adjusted for the potential confounders define above. We used the outcomes in their original units, as well as standardized measures to allow comparability across the different outcomes. We compared the associations for abuse <11 years and between 11-17 years by comparing the point estimates and examining whether 95% confidence intervals (95%CI) overlapped and by using seemingly unrelated estimation to assess the difference between the coefficients. We explored possible sex differences in the associations between childhood abuse and cardiometabolic outcomes in a model including an interaction term between each type of childhood abuse and sex.

We also used linear regression to examine the association between a summary score of abuse types that occurred <18 years (ranging from 0-3) and the cardiometabolic outcomes. We assessed whether there was a dose-response relationship (i.e. increase in the outcomes by increase in the score of abuse) by using the score as continuous and a Wald test for linear trend.

Sensitivity analysis

Considering that different types of childhood abuse commonly co-occur, we performed sensitivity analysis with the types of abuse mutually adjusted to estimate their independent associations.

Mental health can influence the report of childhood abuse, such that individuals with higher psychological distress are more likely to report adverse childhood experiences.[20] Therefore, we also performed sensitivity analysis adjusting for depression at the time of childhood abuse reporting. Depression was measured using the Short Mood and Feelings Questionnaire (SMFQ),[21] a 13-item questionnaire with score ranging between 0–26, in which a greater score represents higher depression.

To explore the frequency of childhood abuse occurrence, we recategorized the occurrence of each type of abuse into the following frequency categories: never, rarely/sometimes and often/very often. As each abuse type was assessed by multiple questions, we applied the response indicating the highest frequency per type. More details are presented in supplementary material.

Missing data

There was missing data on outcomes and covariates. The highest proportion of missing data was observed for insulin at age 18 (44.7%), followed by total cholesterol, HDL, LDL, triglycerides, glucose and CRP (43.7%) at 18 years (Supplementary Table 1). To increase precision and reduce selection bias, we conducted multivariate multiple imputation using chained equations to impute missing information. Twenty cycles of regression switching were used and estimates of results were averaged across the imputed datasets according to Rubin's rules.[22] More details on the imputation models are available in supplementary material.

We also performed analysis in those with complete data on child abuse, covariates and outcomes (complete cases) as a sensitivity analysis.

RESULTS

Table 1 presents characteristics of the participants included in the analysis (*n* = 3,223) compared to those excluded from the analysis. Included participants were more likely to be female, white, and to have a higher socioeconomic position. Cardiometabolic health measures were generally more favourable in included participants (lower BMI, SBP, lipids, except for HDL, and glucose), though differences were relatively small in magnitude. The distribution of data after imputation is similar to the observed data (Supplementary Table 1).

Approximately 5% reported physical abuse, and it was more likely to have occurred <11 years (Table 2). The report of sexual abuse was higher in females (12%) than in males (3%), and whilst in males the prevalence was similar in both age periods, in females it was higher between 11-17 years. Psychological abuse was also more reported by females (14%) than males (10%), and it was more likely to have occurred between 11-17 years. The co-occurrence between the different types of abuse is presented in Supplementary Figure 1. Nearly 20% experienced at least one type of abuse, and physical and psychological abuse commonly co-occurred, such that 65% of those who reported physical abuse also reported psychological abuse (2.4% of the participants). Frequencies of abuse occurrence are reported in Supplementary Table 2.

The majority of the associations between childhood abuse and cardiometabolic outcomes at 18 and 25 years was similar regardless of whether abuse occurred <11 years or between 11-17 years (Supplementary Tables 3 and 4). The exceptions were for the associations of physical abuse with heart rate at both 18 and 25 years, glucose at 18 years, and BMI at 25 years, where stronger associations were observed for physical abuse that occurred between 11-17 years, and between psychological abuse and both glucose and insulin at 25 years, where stronger associations were observed for psychological abuse that occurred <11 years (Supplementary Tables 3 and 4).

Therefore, given the similarity of the results according to the age at which abuse occurred, the main results are reported for abuse experienced at any age <18 years.

Most associations were similar in males and females, and main results are therefore presented for both sexes combined. Sex stratified results are presented in supplementary material.

Cardiometabolic health at 18 years

Unadjusted and adjusted associations of childhood abuse with the cardiometabolic outcomes in their original scale are presented in Supplementary Tables 5 and 6, respectively, and adjusted associations with standardised outcomes are presented in Figures 2 – 4. Physical (β 1.35 kg/m^2, 95%CI 0.66, 2.05), sexual (β 0.57 kg/m^2, 95%CI 0.04, 1.11) and psychological (β 0.47 kg/m^2, 95%CI 0.01, 0.92) abuse were associated with higher BMI at 18 years, even when adjusting for potential confounders. Physical abuse was also associated with lower HDL (β -0.07 mmol/L, 95%CI -0.13, -0.01) and higher CRP (β 31%, 95%CI 1%, 69%), and sexual abuse was also associated with higher heart rate (β 0.57 bpm, 95%CI 0.04, 1.11).

The only evidence for sex differences was observed for the associations between sexual abuse and both BMI and heart rate (p-value for sex interaction=0.052 and 0.048, respectively), which was observed in males (BMI: β 2.15 kg/m^2, 95%CI 0.62, 3.68; heart rate: β 8.07 bpm, 95%CI 2.02, 14.12) but not females (BMI: 0.33 kg/m^2, 95%CI -0.26, 0.93; heart rate: β 1.25 bpm, 95%CI -0.43, 2.93) (Supplementary Table 7).

When the types of abuse were mutually adjusted, the point estimates usually reduced, and there was evidence of an independent association of physical abuse with BMI (β 1.22 kg/m^2, 95%CI 0.47, 1.97) and HDL (β -0.07 mmol/L, 95%CI -0.14, -

0.01), and of sexual abuse with heart rate (β 1.83 bpm, 95%CI 0.15, 3.52) (Supplementary Table 8). When depression was included in the adjustment (Supplementary Tables 9-11), the point estimates were usually attenuated compared to the main analysis, and the associations of physical abuse with higher BMI (β 1.20 kg/m^2, 95%CI 0.50, 1.90) and lower HDL (β -0.06 mmol/L 95%CI -0.12, 0.00), and between sexual abuse and higher heart rate (β 1.79 bpm, 95%CI 0.11, 3.47) were still evident (Supplementary Table 9). When considering the frequency of abuse occurrence, there was evidence of associations of physical abuse and sexual abuse experienced often/very often with higher BMI (Supplementary Table 12). Point estimates for abuse occurring rarely/sometimes (compared to never) were generally smaller and all confidence intervals crossed the null value. The one exception was the association of physical abuse with lower triglycerides in those reporting abuse occurring rarely/sometimes compared to never.

A higher score of childhood abuse was associated with higher BMI and higher heart rate (Table 3). Each additional experience of abuse was associated with, on average, 0.50 kg/m^2 (95%CI 0.23; 0.76) higher BMI, and those who experienced all types of childhood abuse had a 2.29 kg/m^2 (95%CI 0.70; 3.88) higher BMI than those who did not experience any type of abuse in childhood. Those who experienced all types of child abuse also had a 5.43 bpm (95%CI 0.41; 10.46) higher heart rate than those who did not experience any type of abuse. No sex differences were observed for the associations between the score of childhood abuse and cardiometabolic outcomes at age 18 (Supplementary Table 14).

Cardiometabolic health at 25 years

All associations observed at 18 years were also observed at age 25, except for the association between physical abuse and CRP. Additionally, some further associations emerged at age 25. All types of abuse were also associated with higher insulin; physical abuse was associated with 0.3 SD (95%CI 0.1; 0.4) higher insulin, which corresponds to 26% (95%CI 12; 41) higher than those who did not experience physical abuse, sexual abuse was associated with 13% (95%CI 3, 23) higher insulin, and psychological abuse was associated with 9% (95%CI 0, 19) higher insulin (Figures 2 – 4; Supplementary Table 6). Sexual abuse was also associated with lower total cholesterol (β -0.14 mmol/L, 95%CI -0.26, -0.01).

The association between sexual abuse and higher heart rate was stronger in males (β 6.45 bpm, 95%CI 2.66; 10.24) than females (β 1.48 bpm, 95%CI 0.10; 2.86, p-value for sex interaction=0.023), and associations of psychological abuse with both higher triglycerides (β 18%, 95%CI 6, 31) and CRP (β 31%, 95%CI 0, 72) were evident only in males, whilst the association with lower total cholesterol (β -0.14 mmol/L, 95%CI -0.27, -0.02) was only observed in females (Supplementary Table 7).

When the types of abuse were mutually adjusted, there was evidence of independent associations of physical and sexual abuse with BMI and insulin (Supplementary Table 8). Adjustment for depression attenuated the point estimates, and associations of all types of abuse with BMI and of physical and sexual abuse with insulin were still evident (Supplementary Tables 9-11). All of the confidence intervals for abuse occurring rarely/sometimes crossed the null value (Supplementary Table 13). Physical and sexual abuse occurring often/very often were associated with higher BMI (β 1.22kg/m^2, 95%CI 0.32, 2.12, and 1.56 kg/m^2, 95%CI 0.63, 2.50, respectively).

A dose-response relationship was observed between a higher score of childhood abuse and higher BMI, higher insulin, lower total cholesterol and lower HDL

(Table 3). For example, each additional experience of abuse was associated with, on average, 10% (95%CI 5; 15) higher insulin, and experiencing all three types of abuse was associated with 49% (95%CI 16; 92) higher insulin concentration than those who did not experience any type of abuse. Sex differences were observed for the associations between the summary score of abuse and both triglycerides and CRP at 25 years, with stronger associations observed in males than females (Supplementary Table 14).

Associations between child abuse and cardiometabolic outcomes at ages 18 and 25 years were similar when including only complete cases, though in the latter confidence intervals were wider due to more imprecision in the estimates (Supplementary Table 15).

DISCUSSION

This population-based cohort study aimed to assess the associations between childhood abuse and cardiometabolic outcomes in young adults. Childhood abuse (all types and the score of abuse) was consistently associated with higher BMI at 18 and 25 years. At age 25, in addition to associations with BMI, all types of abuse and the score were associated with higher insulin. Additional associations were observed for the specific types of abuse and the abuse score with outcomes at both ages 18 and 25 years (e.g., sexual abuse and higher heart rate at ages 18 and 25, and abuse score and lower HDL at 25 years). There was weaker evidence of an association between child abuse and the other cardiometabolic outcomes assessed (e.g. point estimates for physical and sexual abuse in relation to DBP were consistently positive at both 18 and 25 years of age, but confidence intervals cross the null). Associations between child abuse and cardiometabolic health outcomes were overall similar if abuse occurred <11 years or between 11-17 years. Few associations differed by sex, and when sex differences were evident, males had stronger associations than females.

While our findings are in line with some previous studies that found positive associations between adverse life events and cardiometabolic risk factors such as obesity and blood pressure,[6, 8] not all studies have noted associations between childhood abuse and cardiometabolic health in young adults.[5, 7] A cohort study found no evidence for a relationship between child maltreatment and blood pressure or hypertension in young adults,[7] and a systematic review of 20 studies concluded that there was no evidence of an association between childhood adversity and levels of inflammatory and other CVD immune markers in young people.[5] It is possible that some associations differ by cardiometabolic outcomes or are inconsistent because of the different ages, settings and methods.

A review and meta-analysis of studies investigating the association of childhood maltreatment with obesity found a stronger association for obesity in adulthood (OR 1.38, 95%CI 1.28,1.50), compared to obesity in young people (OR 1.13, 95%CI 0.92, 1.39).[10] In the UK 1958 Birth Cohort, there was no evidence of associations of childhood abuse with BMI at the ages of 16, 23 and 33; associations between physical abuse and BMI became apparent at age 45 in males and females and associations with psychological abuse emerged later, at age 50.[11] In our study of a more contemporary birth cohort (1991-2), associations between all types of abuse in childhood and BMI were already apparent at age 18 and remained at age 25. Furthermore, there was evidence of associations with additional cardiometabolic health measures at ages 18 and 25. These results were overall robust when the types of childhood abuse were mutually adjusted or adjusted for depression, and positive associations with these cardiometabolic outcomes were also observed for a higher score of childhood abuse. Generational differences in obesity levels, frequency and perception of abuse, and chance may play a role in explaining these different findings in the two UK cohorts.

Few studies have explored timing-specific effects of abuse on cardiometabolic health,[2] although there is evidence of different associations by timing of abuse on other outcomes.[23-25] We were able to assess childhood abuse experienced <11 years and between 11-17 years and found that associations with cardiometabolic health were similar. This corroborates previous findings observed for adult cardiometabolic health.[26] However, we have assessed broad age categories and we cannot be certain that they do not mask differences that would be apparent if we could examine timing of exposure by narrower age ranges/life course stages (e.g., early childhood, mid-childhood, early adolescence and late adolescence).[23] Though recall bias due to retrospective report of childhood abuse could affect the associations by timing of childhood abuse, we would expect such bias to affect associations with all outcomes in the same direction. However, we showed that some associations were stronger for abuse occurring <11 years (e.g., the association between psychological abuse and insulin at 25 years), and some were stronger if abuse occurred between 11-17 years (e.g., the association between physical abuse and heart rate). Therefore, recall bias is unlikely to explain the differences by timing of childhood abuse. Previous evidence for mental health suggests that abuse/maltreatment experienced in adolescence have stronger negative consequences on mental health than does abuse/maltreatment experienced only in childhood.[24, 25] Differences by age at abuse in the associations between childhood abuse and cardiometabolic outcomes were still evident when analyses were further adjusted for depression measured using the SMFQ

(Supplementary Tables 10 and 11), suggesting that this may not fully explain the age-specific results found.

We also examined abuse in frequency categories. Associations between childhood abuse and cardiometabolic outcomes were driven mainly by those experiencing more frequent abuse. It will be valuable to repeat this analysis at older ages to see whether adverse cardiometabolic health emerges at a later age in those exposed less frequently or not.

Pathways from abuse in childhood to adverse cardiometabolic health include behavioural, mental health related and biological mechanisms [2] - these are not necessarily mutually exclusive. For example, exposure to maltreatment can cause emotional dysregulation, which in turn may result in developing maladaptive coping strategies, including emotional eating,[27] and subsequent obesity.[28] Childhood abuse may affect cardiometabolic risk through downstream effects on health behaviours (e.g., unhealthy diet or physical inactivity), or direct physiological changes resulting from disruption of regulatory pathways, such as the stress response system.[29] Such cascading effects may explain the further emergence of differences in cardiometabolic health at 25 years, as downstream impacts of abuse in childhood on physical health may take time to appear.

Although most associations were similar in males and females, there were stronger associations between childhood abuse and some cardiometabolic outcomes – heart rate, total cholesterol, triglycerides and CRP – in males. Previous studies assessing associations between childhood maltreatment/victimisation with inflammation[30, 31] and CVD have shown stronger associations in females,[32, 33] others have shown stronger associations with CVD in males,[34, 35] whilst some have observed little evidence of sex differences[36]. Further studies of sex differences are needed, as are studies to elucidated sex specific pathways that can in turn inform sex specific CVD prevention and treatment.

Strengths and Limitations

This study included a large-scale population cohort with repeated measures of multiple biomarkers of cardiometabolic health. Whilst most studies do not consider the age at which childhood abuse occurred, we were able to do so, and showed no consistent differences by timing at exposure to abuse in the associations with cardiometabolic health.

Our study also has several limitations. One limitation is attrition, which is typical of long-term prospective studies and is more common in those from socioeconomically deprived backgrounds.[37] To minimize selection bias, we conducted multiple imputation to impute missing confounders and outcome data. The similarity between results from the complete case analysis (Supplementary Table 15) and the analysis of imputed datasets suggest that results are not substantially affected by selection bias.

The sample is predominantly white and relatively affluent, and this may limit generalizability. Nevertheless, the prevalence of childhood abuse found in our study lies within the range of estimates reported in the UK, where physical abuse ranged from 3.6% to 32.6%, sexual abuse from 0.7% to 27.8%, and psychological abuse from 4.0% to 66.7%.[38]

Abuse was assessed retrospectively by self-report, as is standard in large, population-based studies. However, we used questions that reduce bias by asking about specific acts of violence as opposed to nominal questions about ‘abuse’. Even though ALSPAC has information on childhood abuse collected prospectively, these are mainly reported by the parents and do not cover the entire period before 18 years.

Furthermore, the prospective information on different types of abuse was assessed at different time points, so that investigating and comparing the associations of different abuse types by age at exposure would not be possible.

Retrospective report of abuse can be influenced by concurrent mental health factors,[20] and a recent meta-analysis demonstrated poor agreement between prospective and retrospective measures of child abuse, suggesting that these might identify different groups of individuals.[39] Whilst prospective measures are generally considered more valid and have better specificity,[40] retrospective measures may have better sensitivity. The use of retrospective report of abuse might underestimate associations with objectively measured outcomes, such as cardiometabolic health,[40] and therefore if bias due to retrospective reporting is present, it is likely to have underestimated the associations. It is unlikely that levels of cardiometabolic health markers would influence recall or reporting of childhood abuse. However, mental health and CVD might have a bidirectional relationship,[41] and mental health can influence the report of childhood abuse.[20] Sensitivity analysis adjusting for depression at the time of childhood abuse reporting show overall similar results, and therefore reverse causality in the associations between childhood abuse and cardiometabolic outcomes is unlikely.

We acknowledge that multiple tests have been carried out, which might have increased the risk of type 1 error. Only 12 results would ‘survive’ formally correcting for multiple testing ($p<7.58 \times 10^{-4}$) (Supplementary Table 16). Yet we do not consider each exposure-outcome investigated completely independent and we did not use p-value thresholds to guide our conclusions. We have interpreted our results with caution, based on patterns of results, the magnitude of estimates and their CIs, rather than statistical significance.[42]

Conclusion

Our findings suggest downstream effects of childhood abuse on cardiometabolic risk factors in early adulthood, suggesting that young people who have experienced abuse may benefit from early screening for cardiometabolic health.

Further follow-up with similar cohorts using repeated measures of biomarkers of cardiometabolic health will be valuable in drawing life course trajectories to determine whether these further diverge or otherwise, and whether sex differences are observed. Future research into the mechanisms by which early life abuse affects cardiometabolic health may inform secondary prevention efforts.

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Contributors

AZ, ALGS, SH and AF designed the study, interpreted the data and drafted the manuscript. ALGS and AZ analysed the data. All authors contributed to revising the manuscript critically for important intellectual content. All authors approved the version of the manuscript to be published. The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

Competing interests

None declared.

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Table 1. Characteristics of participants included in the analysis (N = 3,223) and excluded from the analysis due to missing childhood abuse data (N = 11,460)

Characteristics	Participants included in analysis, N (%) or mean (SD)	Participants excluded from analysis, N (%) or mean (SD)	*P v*alue
Gender			< 0.001
Female	2,143 (66.5)	5,051 (44.1)	
Male	1,080 (33.5)	6,409 (55.9)	
Ethnicity, *n* (%)			<0.001
White	2,818 (96.4)	8,492 (94.5)	
Non-White	105 (3.6)	495 (5.5)	
Maternal education, *n* (%)			< 0.001
CSE	285 (8.7)	2,212 (23.8)	
Vocational	209 (7.1)	1,001 (10.8)	
O level	1,000 (33.9)	3,235 (34.8)	
A level	849 (28.7)	1,903 (20.5)	
University degree	638 (21.6)	938 (10.1)	
Paternal education, *n* (%)			< 0.001
CSE	436 (15.0)	2,636 (29.7)	
Vocational	181 (6.3)	815 (9.2)	
O level	610 (21.0)	1,890 (21.3)	
A level	853 (29.4)	2,209 (24.9)	
University degree	820 (28.3)	1,317 (14.9)	
Social Class, *n* (%)			< 0.001
I	144 (5.2)	206 (2.5)	
II	804 (29.3)	1,644 (20.4)	

III (non-manual)	770 (28.0)	1,857 (23.0)	
III (manual)	658 (24.0)	2,549 (31.6)	
IV	308 (11.2)	1,368 (16.9)	
V	62 (2.3)	451 (5.6)	
18-year outcomes			
BMI, kg/m^2	22.6 (4.1)	23.2 (4.4)	<0.001
Heart Rate, bpm	70.1 (10.6)	69.3 (11.2)	0.030
SBP, mmHg	115.7 (11.5)	117.9 (11.5)	<0.001
DBP, mmHg	64.7 (7.6)	64.5 (7.4)	0.414
Total cholesterol, mmol/L	3.8 (0.7)	3.7 (0.7)	0.032
HDL, mmol/L	1.3 (0.3)	1.2 (0.3)	<0.001
LDL, mmol/L	2.1 (0.6)	2.1 (0.6)	0.559
Triglycerides, mg/dL[a]	0.8 (0.4)	0.9 (0.4)	0.034
Glucose, mmol/L[a]	5.0 (0.6)	5.1 (0.6)	0.233
Insulin, mg/dL[a]	8.1 (7.8)	8.7 (8.6)	0.028
CRP, mg/l[a]	1.5 (4.0)	1.7 (6.0)	0.268
25-year outcomes			
BMI kg/m^2	24.7 (5.0)	25.3 (5.2)	0.001
Heart Rate, bpm	70.1 (10.6)	69.3 (11.2)	0.030
SBP, mmHg	115.5 (11.2)	117 (11.7)	<0.001
DBP, mmHg	67.1 (7.9)	66.7 (8.0)	0.127
Total cholesterol, mmol/L	4.4 (0.8)	4.5 (0.9)	0.001
HDL, mmol/L	1.6 (0.4)	1.5 (0.4)	0.020
LDL, mmol/L	2.4 (0.7)	2.5 (0.8)	<0.001
Triglycerides, mg/dL[a]	0.9 (0.5)	1.0 (0.7)	<0.001
Glucose, mmol/L[a]	5.3 (0.6)	5.4 (0.8)	<0.001
Insulin, mg/dL[a]	9.6 (9.2)	10.0 (10.0)	0.258

CRP, mg/l[a]	2.2 (5.3)	2.4 (8.6)	0.443

BMI: body mass index, Cholesterol: total cholesterol, CRP: C-reactive protein, DBP: diastolic blood pressure; HDL: high-density lipoprotein cholesterol; LDL: low-density lipoprotein cholesterol; SBP: systolic blood pressure

[a] Median (inter-quartile range); P-values are for comparison of log transformed values.

Social occupation: I: Professional occupation, II: Managerial and technical occupations, III: Skilled occupation, IV: Partly-skilled occupation, V: unskilled occupations

Table 2. Prevalence of childhood abuse according to sex (N = 3,223)

	< 11 years % (95%CI)	11-17 years % (95%CI)	< 18 years % (95%CI)
Males *(n = 1,080)*			
Physical abuse	4.8 (3.4, 6.1)	0.5 (0.0, 1.0)	5.0 (3.6, 6.3)
Sexual abuse	2.0 (1.1, 3.0)	1.9 (1.0, 2.8)	3.4 (2.3, 4.6)
Psychological abuse	0.8 (0.2, 1.4)	10.2 (8.3, 12)	10.2 (8.4, 12.1)
Females *(n = 2,143)*			
Physical abuse	5.1 (4.1, 6.0)	0.7 (0.3, 1.0)	5.1 (4.1, 6.1)
Sexual abuse	5.1 (4.1, 6.0)	8.9 (7.7, 10.2)	12.0 (10.6, 13.4)
Psychological abuse	1.0 (0.6, 1.4)	13.6 (12.1, 15.1)	13.7 (12.2, 15.2)

Table 3. Adjusted association between score of child abuse and cardiometabolic outcomes at 18 and 25 years (N = 3,223)

	Score of childhood abuse				p-value*
	1 type of abuse	2 types of abuse	3 types of abuse	Continuous	
	β (95%CI)	β (95%CI)	β (95%CI)	β (95%CI)	
18-year outcomes					
BMI, kg/m^2	0.34 (-0.07, 0.75)	1.44 (0.46, 2.42)	2.29 (0.70, 3.88)	0.50 (0.23, 0.76)	<0.001
Heart rate, bpm	0.43 (-0.84, 1.69)	1.19 (-1.16, 3.54)	5.43 (0.41, 10.46)	0.84 (0.04, 1.64)	0.041
SBP, mmHg	0.20 (-1.03, 1.43)	0.07 (-1.88, 2.02)	0.64 (-3.71, 4.99)	0.10 (-0.73, 0.94)	0.804
DBP, mmHg	0.26 (-0.62, 1.13)	1.25 (-0.24, 2.74)	1.41 (-1.77, 4.58)	0.34 (-0.24, 0.93)	0.246
Cholesterol, mmol/L	-0.01 (-0.10, 0.09)	-0.10 (-0.28, 0.07)	-0.10 (-0.39, 0.19)	-0.02 (-0.08, 0.03)	0.403
HDL, mmol/L	-0.01 (-0.05, 0.02)	-0.10 (-0.19, 0.0)	-0.06 (-0.19, 0.07)	-0.01 (-0.04, 0.01)	0.234
LDL, mmol/L	0.02 (-0.06, 0.09)	-0.07 (-0.22, 0.08)	-0.01 (-0.28, 0.26)	0.00 (-0.06, 0.05)	0.845
Triglycerides, mmol/L [a]	0.98 (0.93, 1.03)	1.04 (0.95, 1.15)	0.93 (0.79, 1.09)	0.98 (0.96, 1.01)	0.202
Glucose, mmol/L [a]	1.00 (0.99, 1.01)	1.01 (0.99, 1.03)	1.00 (0.96, 1.04)	1.00 (0.99, 1.01)	0.928
Insulin, mg/dL [a]	0.99 (0.93, 1.06)	1.22 (1.07, 1.40)	0.97 (0.77, 1.22)	0.99 (0.95, 1.04)	0.815
CRP, mg/l [a]	1.06 (0.93, 1.22)	1.04 (0.80, 1.34)	1.48 (0.79, 2.79)	1.11 (1.00, 1.22)	0.051
25-year outcomes					

BMI, kg/m^2	0.56 (0.06, 1.06)	1.44 (0.46, 2.42)	2.75 (0.80, 4.71)	0.71 (0.39, 1.03)	<0.001
Heart rate, bpm	0.50 (-0.77, 1.77)	1.19 (-1.16, 3.54)	4.64 (-0.38, 9.66)	0.77 (-0.07, 1.61)	0.070
SBP, mmHg	0.16 (-0.99, 1.32)	0.07 (-1.88, 2.02)	0.54 (-3.65, 4.74)	0.11 (-0.55, 0.77)	0.741
DBP, mmHg	0.40 (-0.47, 1.27)	1.25 (-0.24, 2.74)	1.56 (-1.84, 4.95)	0.52 (0.00, 1.05)	0.052
Cholesterol, mmol/L	-0.06 (-0.16, 0.04)	-0.10 (-0.28, 0.07)	-0.40 (-0.75, -0.05)	-0.07 (-0.13, -0.01)	0.017
HDL, mmol/L	-0.03 (-0.07, 0.01)	-0.10 (-0.19, 0.00)	-0.13 (-0.31, 0.06)	-0.04 (-0.07, -0.01)	0.010
LDL, mmol/L	-0.05 (-0.12, 0.03)	-0.07 (-0.22, 0.08)	-0.21 (-0.50, 0.09)	-0.05 (-0.1, 0.00)	0.060
Triglycerides, mmol/L [a]	1.02 (0.97, 1.08)	1.04 (0.95, 1.15)	0.94 (0.79, 1.12)	1.01 (0.98, 1.05)	0.460
Glucose, mmol/L [a]	1.00 (0.99, 1.01)	1.01 (0.99, 1.03)	1.03 (0.99, 1.07)	1.00 (1.00, 1.01)	0.205
Insulin, mg/dL [a]	1.06 (0.99, 1.14)	1.22 (1.07, 1.40)	1.49 (1.16, 1.92)	1.10 (1.05, 1.15)	<0.001
CRP, mg/l [a]	0.99 (0.85, 1.16)	1.04 (0.80, 1.34)	1.22 (0.71, 2.10)	1.02 (0.94, 1.11)	0.659

Adjusted for age, sex, ethnicity, maternal education, paternal education, and parental social class

BMI: body mass index, Cholesterol: total cholesterol, CRP: C-reactive protein, DBP: diastolic blood pressure; HDL: high-density lipoprotein cholesterol; LDL: low-density lipoprotein cholesterol; SBP: systolic blood pressure

*p-value for linear trend

[a] Logged outcome variables were back transformed (exponentiated) and are interpreted as the percentage change in those who experienced abuse compared to those who did not experience that abuse, or per additional abuse type experienced on the abuse score.

In the associations for the score of abuse, 0 (no experience of abuse) is the reference category.

Figure Titles

Figure 1. Study flow

Figure 2. Adjusted associations of physical abuse with cardiometabolic health outcomes at 18 and 25 years (N = 3,223). Point estimates are mean differences of standardized outcome values in individuals who reported physical abuse compared to those who did not.

Figure 3. Adjusted associations of sexual abuse with cardiometabolic health outcomes at 18 and 25 years (N = 3,223). Point estimates are mean differences of standardized outcome values in individuals who reported sexual abuse compared to those who did not.

Figure 4. Adjusted associations of psychological abuse score with cardiometabolic health outcomes at 18 and 25 years (N = 3,223). Point estimates are mean differences of standardized outcome values in individuals who reported psychological abuse compared to those who did not.

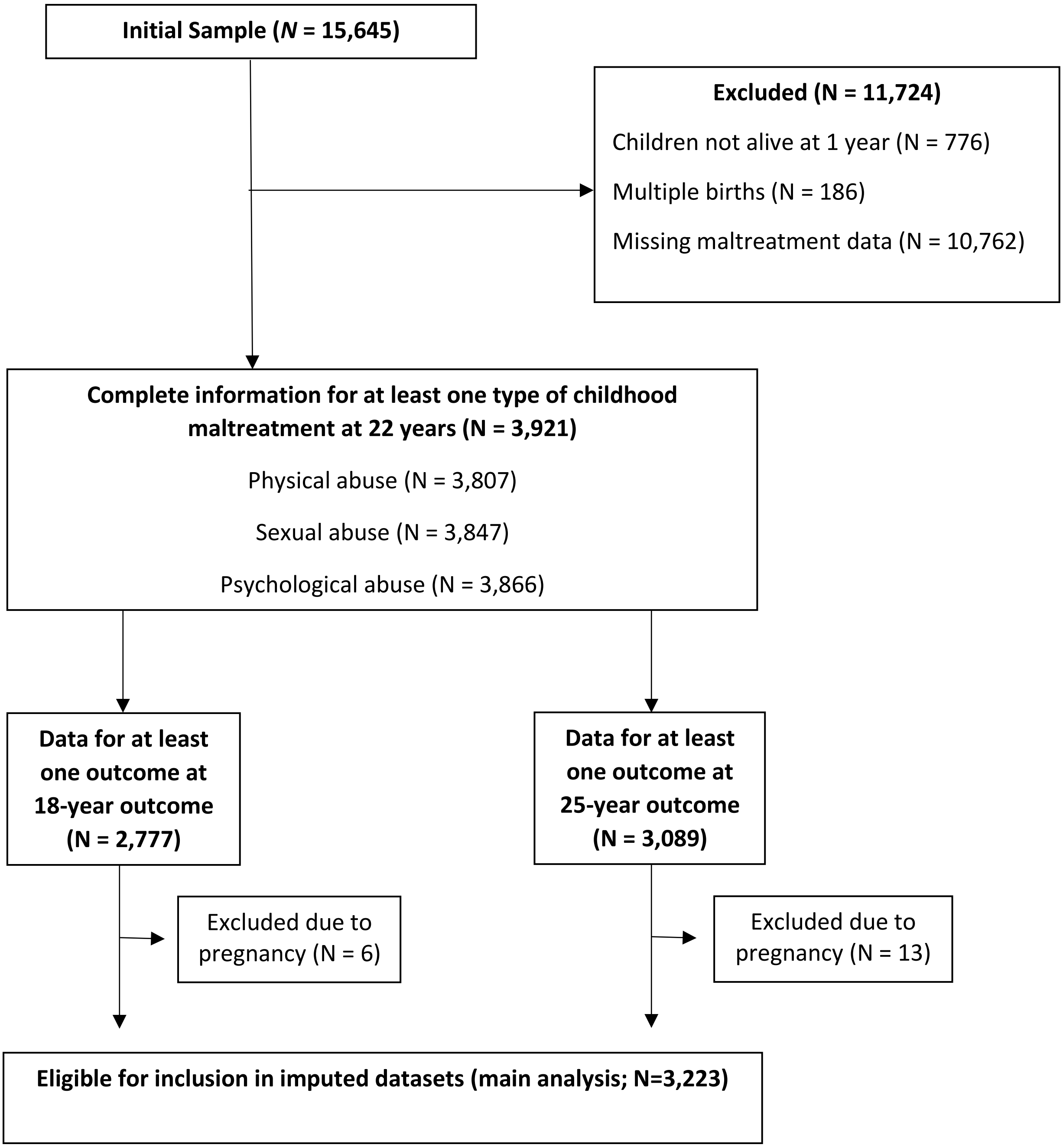

Figure 1. Study flow.

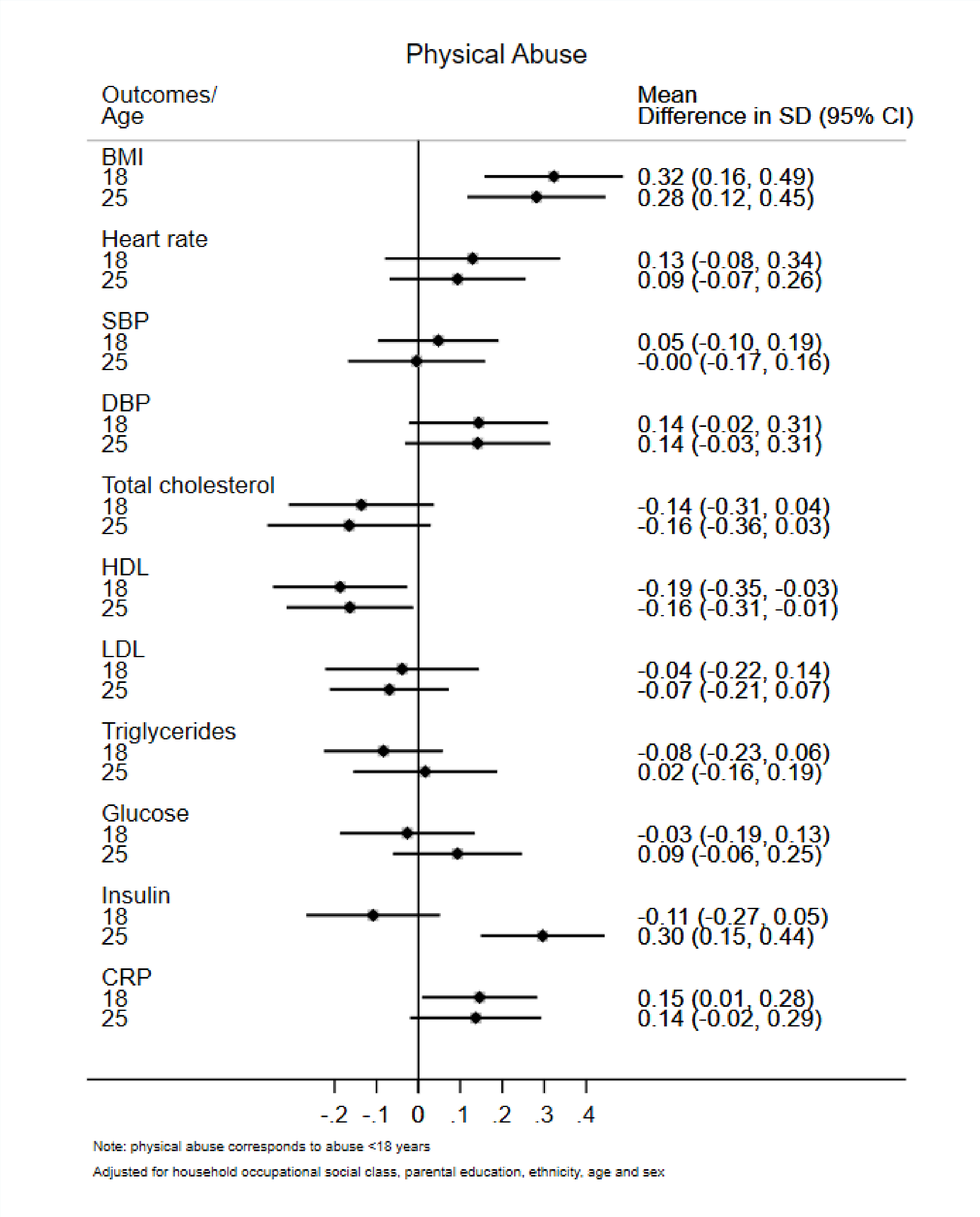

Figure 2. Adjusted associations of physical abuse with cardiometabolic health outcomes at 18 and 25 years (N = 3,223). Point estimates are mean differences of standardized outcome values in individuals who reported physical abuse compared to those who did not.

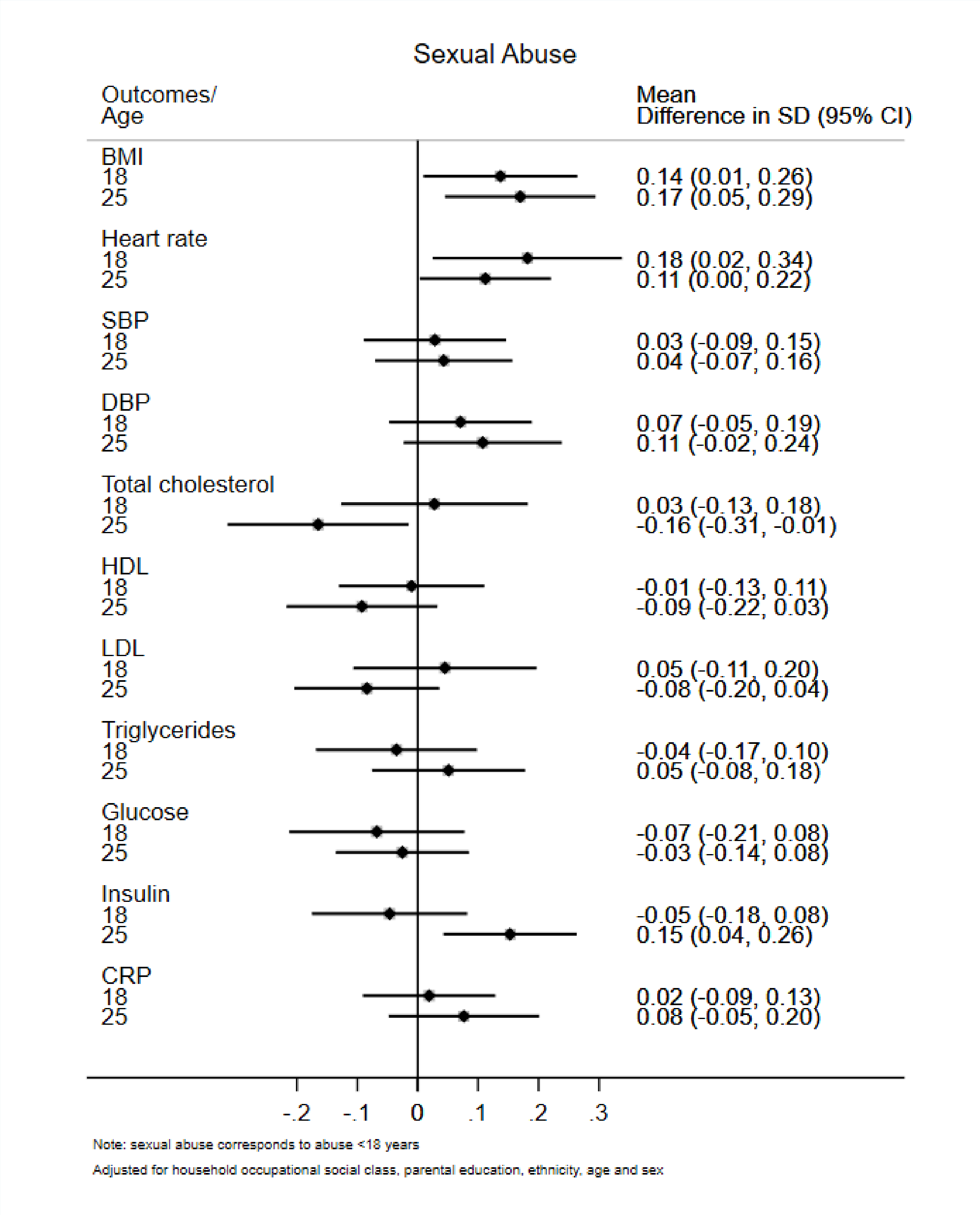

Figure 3. Adjusted associations of sexual abuse with cardiometabolic health outcomes at 18 and 25 years (N = 3,223). Point estimates are mean differences of standardized outcome values in individuals who reported sexual abuse compared to those who did not.

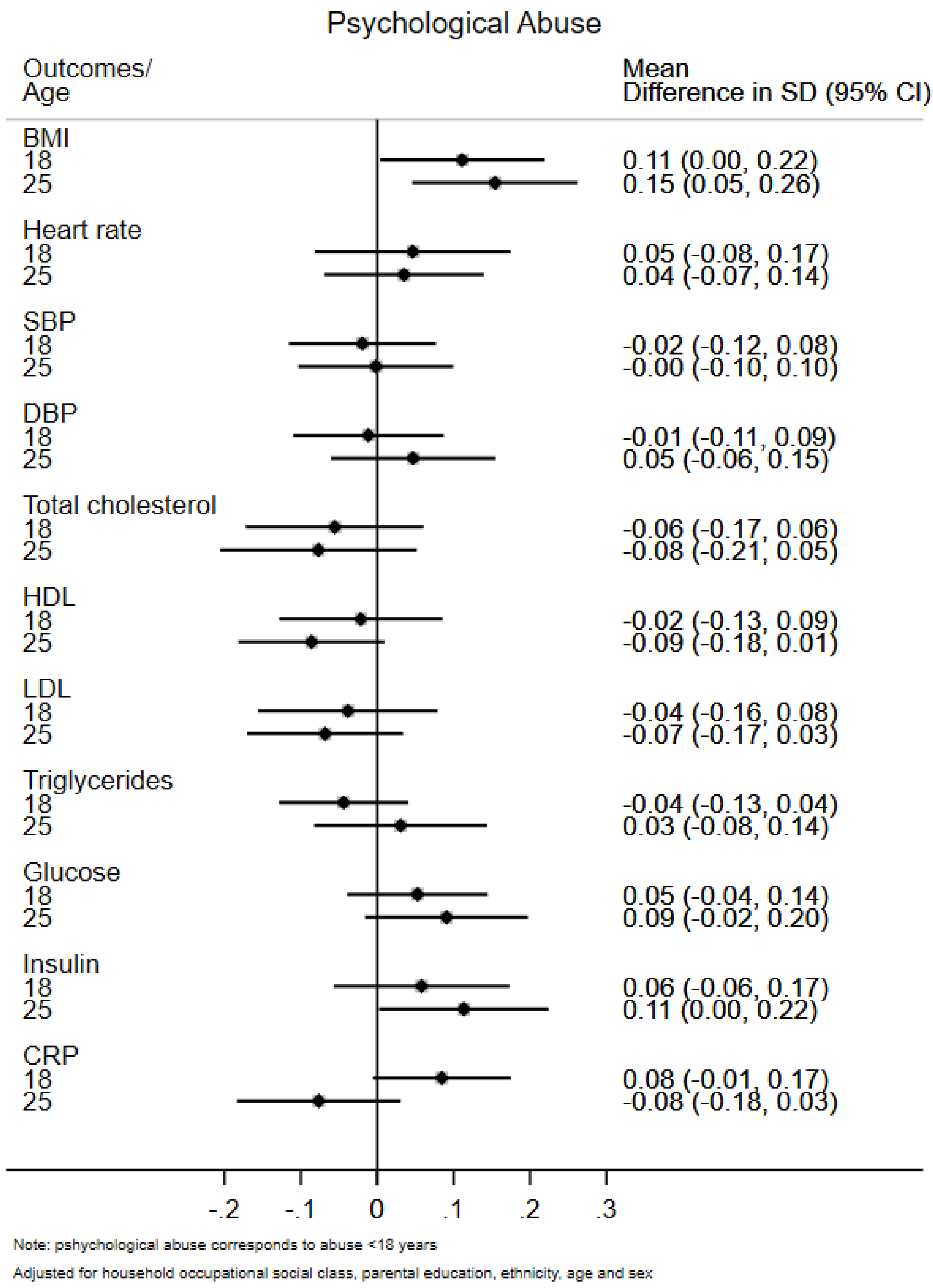

Figure 4. Adjusted associations of psychological abuse score with cardiometabolic health outcomes at 18 and 25 years (N = 3,223). Point estimates are mean differences of standardized outcome values in individuals who reported psychological abuse compared to those who did not.