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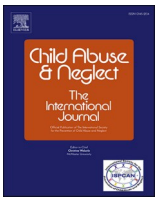

The age of onset and duration of childhood abuse: An extension of the childhood trauma screener

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ABSTRACT

Background: Childhood abuse is a significant risk factor for worse adult mental and physical health. Although reported as important moderators, only a few studies have analyzed the effects of the age of onset and duration of abuse, particularly including potential sex differences.
Objective: To investigate the impact of timing and severity of childhood abuse on adult mental and physical health issues, with an emphasis on sex differences.
Participants and settings: Data from 2412 participants (52 % women, 28–89 years) of the general population.
Methods: The Childhood Trauma Screener (CTS) was extended to assess the severity additionally to the age of onset and cumulative exposure across predefined age intervals of physical, emotional, and sexual childhood abuse. Associations with adult health behavior, mental health issues, and inflammatory markers were investigated using regression analyses, complemented by sex interactions.
Results: An earlier onset of emotional abuse was associated with lower resilience ($b = -0.51$, $p = 0.034$), whereas greater cumulative exposure to emotional abuse was associated with an earlier onset of depression ($b = -4.53$, $p = 0.041$) and more severe depressive symptoms ($b = 0.94$, $p = 0.049$). Effect directions differed between men and women for associations between the age of onset of emotional abuse and C-reactive protein levels ($b = -0.03$, $p = 0.042$) as well as the cumulative exposure of emotional abuse and fibrinogen levels ($b = 0.04$, $p = 0.007$).
Conclusions: The findings underscore the significance of both severity and timing on adult health outcomes, with notable sex differences. These results support the need for targeted prevention programs that consider multiple maltreatment aspects, along with tailored interventions based on sex-specific vulnerabilities.

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1. Background

Childhood maltreatment (CM) increases the risk of adult mental and physical diseases. More precisely, doubled to quadrupled chances of depressive and anxiety disorders were reported (Carr, Duff, & Craddock, 2020; Hughes et al., 2017; Klinger-König et al., 2024). For somatic diseases, such as cancer, cardiovascular diseases, or diabetes, the chances are increased by 20 % to 130 %, varying between condition and study (Hughes et al., 2017; Klinger-König et al., 2024). According to the World Health Organization (WHO), CM is defined as the experience of abuse or neglect as a minor (World Health Organization, 2020); often divided into five subtypes: physical, emotional, and sexual abuse and physical and emotional neglect (Bernstein et al., 2003; Grabe et al., 2012). The prevalence of CM varies worldwide with the highest transnational prevalence of emotional abuse (29.2 % in Europe to 46.7 % in Africa), and, overall, a lower prevalence in Western countries (Stoltenborgh, Bakermans-Kranenburg, Alink, & van Ijzendoorn, 2015).

According to a huge US study, the prevalence of CM decreases slightly until the age of eleven (Kim & Drake, 2019). An earlier onset of CM was associated with higher levels of inflammation in children, a higher risk of childhood posttraumatic stress disorder (PTSD), lower educational achievements as well as more depressive and anxiety symptoms in adulthood (Ehrlich, Miller, Rogosch, & Cicchetti, 2021; Famularo, Fenton, Kinscherff, Ayoub, & Barnum, 1994; Kaplow & Widom, 2007). In contrast, a later onset of CM was associated with more externalizing behavior, preceding antisocial behavior and alcohol abuse in adulthood (Kaplow & Widom, 2007; Russotti et al., 2021). Besides, a longer duration of CM was associated with both externalizing and internalizing behaviors, the latter also linked to adult depression and anxiety symptoms (Russotti et al., 2021). Further, more internalizing symptoms were associated with higher C-reactive protein (CRP) levels in children with recent CM (Cicchetti, Handley, & Rogosch, 2015).

Unfortunately, only a few studies did investigate different CM subtypes. Manly, Kim, Rogosch, and Cicchetti (2001) found that children presented more aggressive behavior after emotional maltreatment or physical abuse if experienced as infants, toddlers, or preschoolers. In contrast, the same study found that physical neglect experienced by preschoolers was rather associated with internalizing behavior and withdrawal (Manly et al., 2001). Additionally, physical neglect had the highest probability of multiple episodes according to Kim and Drake (2019). These results indicate that the impact of the age of onset and duration of the CM might vary between different subtypes.

However, most studies investigating the impact of CM on adult mental and physical health issues did not take the age of onset of CM into account. For example, Ben-David, Jonson-Reid, Drake, and Kohl (2015) investigated the potential predictors of the age of onset of CM perpetration in adults. Although the study discovered an association with the own CM, it did not investigate the age of onset of this CM (Ben-David et al., 2015). Further, several studies reported a younger age at first depressive episodes after CM but neglected the age of onset of CM as a potential factor (Dong et al., 2024; Nelson, Klumparendt, Doebler, & Ehring, 2017; Struck et al., 2020).

Independent of the age of onset, CM was associated with low-grade inflammation in adults, indicated by higher white blood cell counts (WBC), higher CRP, and higher fibrinogen levels (Danese, Pariante, Caspi, Taylor, & Poulton, 2007). Further, emotional maltreatment was associated with depression and anxiety (Dong et al., 2024; Struck et al., 2020; Teicher, Gordon, & Nemeroff, 2022), but physical maltreatment was rather associated with substance abuse, schizophrenia, and mania (Halpern et al., 2018; Struck et al., 2020).

Results on potential sex differences vary from stronger associations between physical abuse and depression for women to higher rates of physical abuse in depressed men (Dong et al., 2024; Gallo, Munhoz, Loret de Mola, & Murray, 2018). Additionally, Abajobir, Kisely, Maravilla, Williams, and Najman (2017) reported more risky sexual behavior for women only in substantiated sexual abuse. Hence, sex-specific associations might not only depend on the type of CM but also on timing characteristics of the CM, such as duration and age of onset.

To investigate this assumption, we used an extended version of the Childhood Trauma Screener (CTS) (Grabe et al., 2012) in the present study. Precisely, we assessed the age of onset of physical, emotional, and sexual abuse as well as their occurrence during three age intervals (0–5 years, 6–10 years, and 11–15 years) in a large adult general population-based cohort and estimated the impact of both the age of onset and cumulative exposure across the age intervals of each type of childhood abuse on adult health behavior, inflammation markers, and mental health. Additionally, potential sex differences in these associations were investigated.

2. Methods

2.1. Study sample

Data from the Study of Health in Pomerania (SHIP) were used (Völzke et al., 2022). SHIP investigates risk and protective factors of mental and physical diseases in the adult general population of Northeast Germany. So far, data from two independent cohorts is available (SHIP-START-0: 1997–2001, $N = 4308$; SHIP-TREND-0: 2008–2012, $N = 4420$). For both cohorts, a two-stage stratified cluster sample (stratified for age, sex, and city/county of residence) was drawn from the local population registry of the same local area. Participants comprised German citizens aged 20–79 years with German language skills and without institutionalization. Within the second cohort, CM was assessed during the baseline (SHIP-TREND-0: 2008–2012; N = 4420) and the first follow-up assessment (SHIP-TREND-1: 2016–2019; $N = 2507$). The present analyses were based on 2412 participants with complete data on the CTS at both time points.

The SHIP studies were approved by the institutional review board of the University Greifswald. Assessments and analyses were conducted according to the Declaration of Helsinki, including written informed consent of all participants.

2.2. Childhood maltreatment

CM was assessed using the CTQ (Bernstein et al., 2003) in SHIP-TREND-0 and the CTS (Grabe et al., 2012) in SHIP-TREND-1. The CTQ is a self-report questionnaire assessing five subtypes of CM (physical, emotional, and sexual abuse and physical and emotional neglect). The CTS is a five-item ultra-short version of the CTQ assessing CM with one item for each CTQ subscale. Each item is rated on a five-point scale (1 – never; 2 – rarely; 3 – sometimes; 4 –often; 5 - very often); higher CTS summary scores (range: 5–25) indicate more severe CM. A comparison between the CTQ and CTS in SHIP-TREND-0 is described in the supplement and Table S1. To assess the age at abuse in SHIP-TREND-1, the items for physical, emotional, and sexual abuse were each extended to include both the self-reported exact age of onset as well as three multiple-choice age intervals: 0 to 5 years, 6 to 10 years, and 11 to 15 years (CTS+). The intervals were designed, on the one hand, to assist participants who could not recall their exact age and, on the other hand, to reflect key developmental stages: early childhood, primary school age, and adolescence. To estimate the cumulative exposure across the age intervals of the abuse, the number of age intervals reported for each abuse item was counted (hereafter: cumulative exposure). Both the exact age of onset and the age intervals were only presented if the respective childhood abuse item was reported at least "2 – rarely".

2.3. Socio-demographics, lifestyle, and psychometrics

Through computer-assisted face-to-face interviews, socio-demographics were assessed including age and sex. Lifetime smoking was defined as never smoking vs. former or current smoking. Former and current smokers were asked for their age at smoking initiation. Alcohol consumption was measured as grams (g) of ethanol per day (d), averaged over the past 30 days. According to Baumeister et al. (2005), risky alcohol consumption was defined as $\geq$ 20 g/d for women and $\geq$ 30 g/d for men.

During physical examinations, body height and weight were measured with participants standing in an upright position without shoes. Body height was measured to the nearest 1 cm; body weight was measured to the nearest 100 g. The body mass index (BMI) was calculated, and obesity was defined as a BMI $\geq$ 30 kg/m^2.

Lifetime MDD was assessed via the Munich-Composite International Diagnostic Interview (M-CIDI) (Wittchen, Lachner, Wunderlich, & Pfister, 1998). The M-CIDI is a standardized interview assessing multiple mental disorders according to the 4th version of the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) (American Psychiatric Association, 2005). In German samples, the test-retest reliability of any MDD was good ($\kappa = 0.68$) and a moderate agreement was found with measurements of current depressive symptoms ($\kappa \approx 0.45$) (Loerch, Szegedi, Kohnen, & Benkert, 2000; Maske et al., 2015; Wittchen et al., 1998). Additionally, the reliability of the age of onset for the first single depressive episode was excellent (ICC = 0.97) (Wittchen et al., 1998). The dichotomous variable of a lifetime MDD diagnosis and the age of the first depressive episode was used for the present analyses.

Current depressive symptoms were assessed via the depression module of the patient health questionnaire (PHQ-9) (Kroenke & Spitzer, 2002). The PHQ-9 uses nine items covering the symptoms of criterion A of MDD as described in the DSM-IV to assess the severity of depressive symptoms during the past two weeks. A high validity of the German PHQ-9 was found (e.g. $r = 0.73$ with depression and $r = 0.59$ with distress) (Kroenke & Spitzer, 2002; Martin, Rief, Klaiberg, & Braehler, 2006). A summary score was calculated (range: 0–27) with higher scores indicating more severe depressive symptoms.

Resilience was assessed using a short form of the Resilience Scale (RS-11) (Schumacher, Leppert, Gunzelmann, Strauß, & Brähler, 2005). The self-report questionnaire uses eleven items, each rated on a seven-point scale (range: 1 – strongly disagree to 7 – strongly agree). The RS-11 is highly correlated with the longer version based on 25 items ($r = 0.95$) (Schumacher et al., 2005). Additionally, a good validity of the German RS-11 was demonstrated (e.g. r = 0.59 with self-esteem) (Kocalevent et al., 2015). A summary score was calculated with higher scores indicating stronger resilience.

2.4. Inflammatory markers

Fasting blood samples were taken from the cubital vein. Serum and plasma samples were stored at −80 °C in the Integrated Research Biobank of the University Medicine Greifswald and used following its regulations (Winter et al., 2020). WBC was quantified in EDTA blood using the Sysmex XT2000, XE 5000, or SE9000 analyzers (Sysmex Deutschland GmbH, Norderstedt, Germany) or the Advia 2120i (Siemens Healthcare Diagnostics, Eschborn, Germany). High-sensitivity CRP (hs-CRP) levels were measured in serum by nephelometry on the Dimension VISTA (Siemens Healthcare Diagnostics, Eschborn, Germany). Plasma fibrinogen levels were determined according to Clauss using the BCS or the BCS XP system (Siemens Healthcare Diagnostics, Eschborn, Germany). All inflammatory markers were log-transformed before statistical analyses.

2.5. Statistical analyses

Statistical analyses were conducted via STATA/SE 18.0 (StataCorp, 2023). Descriptive statistics are presented as mean and standard deviation (M [SD]) as well as Median and 25 % and 75 % percentile (Median [25 %; 75 %]).

2.5.1. Test-retest reliability

To fortify the validity of the analyses on the age of onset and cumulative exposure, we quantified the seven-year test-retest-reliability of the assessment of CM in SHIP-TREND-0 and SHIP-TREND-1. Averaged two-way mixed effect intra-class correlations (ICC) with absolute agreement were calculated (Goltermann et al., 2023). The absolute difference between the CTS summary scores and the CTS items was calculated to quantify the discrepancy between assessments more accurately. Additionally, linear regressions were

modeled between the CTS at SHIP-TREND-0 and SHIP-TREND-1 adjusting for the interval between both time points. Integrating the results of earlier studies, interaction effects between age, sex, depressive symptoms at SHIP-TREND-0, depressive symptoms at SHIP-TREND-1, and the age of onset with the SHIP-TREND-1-items of the CTS were added to the linear regressions to investigate if our test-retest reliability was modified by these variables (Aalsma, Zimet, Fortenberry, Blythe, & Orr, 2002; Goltermann et al., 2023). Regression coefficients (b), 95 %-confidence intervals (95 %-CI), and *p*-values (p) are reported. Please note that age of onset was only available for items related to childhood abuse.

2.5.2. Associative analyses

Associative analyses were calculated only in SHIP-TREND-1. First, pre-described associations of childhood abuse with unhealthy lifestyles (i.e. smoking, risky alcohol consumption, and obesity), inflammatory markers (i.e. hs-CRP, fibrinogen, and WBC), and mental health issues (i.e. lifetime depression, current depressive symptoms, and resilience) were replicated. The childhood abuse items were used as continuous predictors of interest in all analyses to model an association between the severity of the abuse and the respective outcome. Secondly, all analyses were repeated using the exact age of onset of the respective abuse as a continuous predictor to investigate if a younger age of onset is associated with an unhealthier lifestyle and health issues during adulthood. Finally, the cumulative exposure to abuse was entered as a categorical predictor of interest with reporting one age interval as the reference category. Due to small groups, the cumulative exposure to two or three age intervals was combined to "2+".

Continuous outcomes (i.e. age at smoking initiation, hs-CRP, fibrinogen, WBC, age at first depressive episode, current depressive symptoms, and resilience) were integrated into linear regression models; b, 95 %-CI, and p are reported. Dichotomous outcomes (i.e. lifetime smoking, current risky alcohol consumption, current obesity, lifetime MDD) were integrated into logistic regression models; odds ratios (OR), 95 %-CI, and p are reported. All regressions were adjusted for age and sex. Analyses including inflammatory markers were additionally adjusted for the fasting time before blood sampling. The age of onset was added as a covariate for analyses on cumulative exposure as it naturally limits the number of reported age intervals. Robust standard errors were calculated for all regressions. Sample sizes varied due to missing data for the outcome variables. To investigate potential sex differences, interaction effects

Table 1
Descriptive statistics of the SHIP-TREND-1 sample ($N = 2412$).

	SHIP-TREND-1					
	N Missing	M / %	SD	25 % Perc.	Median	75 % Perc.
Age [Years]	–	56.9	13.8	46	57	68
Sex [Women]	–	51.6				
Fasting [h:min]	–	9:46	4:59	3:09	11:47	13:29
Obesity [Yes]	–	29.5				
Risky alcohol consumption [Yes]	–	10.4				
Lifetime smoking [Yes]	20	64.8				
Age at smoking initiation [Years]	*5*	*17.9*	*5.0*	*15*	*17*	*19*
Fibrinogen [g/l]	26	2.8	0.6	2.4	2.7	3.1
C-reactive protein [mg/l]	59	2.4	4.7	0.7	1.2	2.6
White blood cell count [Gpt/l]	6	6.1	1.8	4.9	5.8	6.9
Lifetime MDD [Yes]	51	18.7				
Age at first depressive episode [Years]	*4*	*40.5*	*14.3*	*30*	*42*	*52*
PHQ-9 summary score [range: 0–27]	19	3.4	3.3	1	3	5
RS-11 summary score [range: 11–77]	19	61.2	11.7	56	63	70
Emotional neglect [range: 1–5]	–	1.7	1.0	1	1	2
Physical neglect [range: 1–5]	–	2.0	1.3	1	1	3
Physical abuse [range: 1–5]	–	1.3	0.7	1	1	1
Age of onset [Years]	*46*	*7.2*	*2.8*	*6*	*7*	*8*
Cumulative exposure	*15*					
1 age interval	–	*59.0*				
2 age intervals	–	*34.6*				
3 age intervals	–	*6.4*				
Emotional abuse [range: 1–5]	–	1.2	0.7	1	1	1
Age of onset [Years]	*39*	*8.2*	*3.4*	*6*	*8*	*11*
Cumulative exposure	*20*					
1 age interval	–	*62.9*				
2 age intervals	–	*26.6*				
3 age intervals	–	*10.5*				
Sexual abuse [range: 1–5]	–	1.1	0.4	1	1	1
Age of onset [Years]	*10*	*9.3*	*3.2*	*6*	*10*	*12*
Cumulative exposure	*4*					
1 age interval	–	*85.6*				
2 age intervals	–	*13.4*				
3 age intervals	–	*1.0*				
CTS summary score [range: 5–25]	–	7.3	2.7	5	6	9

The age of onset of the respective abuse was asked of participants reporting the abuse at least "2 – rarely". For the analyses, the cumulative exposure to two or three age intervals was combined to "2+".
M: mean; SD: standard deviation; Perc.: percentile.

between the CTS items and sex were integrated into separate models. For all potential sex interactions, the number of men and women for continuous outcomes and the number of men and women with or without the dichotomous outcome were checked before the regressions. Due to small groups, interactions between the age of onset and the cumulative exposure to sexual abuse and sex were omitted from the analyses.

3. Results

3.1. Descriptive statistics

The final sample included 2412 participants with complete data on the CTS at both time points. The assessment interval between SHIP-TREND-0 and SHIP-TREND-1 varied between 4.9 and 10.3 years (M = 7.4 [0.7]; Median = 7.3 [7.0; 7.5]). The sample included 1244 women (51.6 %). Age ranged between 20 and 82 (M = 49.6 [13.8]; Median = 49 [39; 60]) at SHIP-TREND-0 and between 28 and 89 (M = 56.9 [13.8]; Median = 57 [46; 68]) at SHIP-TREND-1. A more detailed description of the SHIP-TREND-1 sample is presented in Table 1. All participants reporting childhood abuse at least "2 - rarely" were asked for the age of onset and the age intervals of the abuse. The exact age of onset was reported by 88.7 %, 87.3 %, and 90.1 % of these participants for physical, emotional, and sexual abuse, respectively; 96.3 %, 93.5 %, and 96.0 % reported at least one age interval.

3.2. Test-retest- reliability

The absolute and relative frequencies of the CTS item responses are presented in Table 2. Good test-retest-reliabilities were observed for the CTS summary score (ICC = 0.77 [0.75; 0.79], $p < 0.001$) and four items (ICC range = 0.69–0.78, all $p < 0.001$). Only the ICC for physical neglect was lower (ICC = 0.51 [0.47; 0.55], $p < 0.001$). The CTS items were answered very similarly at both time points (Table 3): Focusing on abuse, 73 % of the participants answered identically to the three items; for 93 % of the participants, the answers differed by one point in maximum. High associations were also found after the adjustment for the time interval between SHIP-TREND-0 and SHIP-TREND-1 (Table 3).

The reliability of the CTS summary score was slightly lower with the increasing age of the participants (b = −0.01 [95 %-CI: −0.01; −0.002], $p = 0.001$). Further, the reliabilities of physical abuse (b = 0.12 [95 %-CI: 0.01; 0.23], $p = 0.041$) and sexual abuse (b = 0.30 [95 %-CI: 0.01; 0.59], $p = 0.046$) were stronger for women than for men. No further associations with age or sex were observed (all $p > 0.05$). More depressive symptoms at SHIP-TREND-0 were associated with a slight increase in the test-retest reliability of the CTS summary score (b = 0.01 [95 %-CI: 0.003; 0.02], $p = 0.009$) and both emotional maltreatment items (neglect: b = 0.02 [95 %-CI: 0.01; 0.03], p = 0.001; abuse: b = 0.02 [95 %-CI: 0.01; 0.03], p = 0.001). On the other hand, more depressive symptoms at SHIP-TREND-1 were associated with a slight increase in the test-retest reliability of physical neglect (b = 0.01 [95 %-CI: 0.001; 0.02], $p = 0.029$). No further associations with depressive symptoms were found (all $p > 0.05$). Finally, there was no association between the test-retest-reliability of all abuse items and the respective age of onset (all $p > 0.05$).

A discussion of the test-retest reliability and the comparison between SHIP-TREND-0 and SHIP-TREND-1 is provided in the supplement.

3.3. Associative analyses

3.3.1. Abuse severity

More severe childhood abuse was consistently associated with worse mental health, namely, an increased probability of lifetime MDD and more severe current depressive symptoms, a younger age at first depressive episode as well as lower resilience (Table S2). For women compared to men, a stronger association was found between physical abuse and current depressive symptoms (see Fig. 1A; physical abuse * sex: b = 0.68 [95 %-CI: 0.25; 1.11], $p = 0.002$; women: b = 0.95 [95 %-CI: 0.60; 1.30], $p < 0.001$; men: b = 0.27 [95

Table 2
Descriptive statistics of the CTS in SHIP-TREND-0 and SHIP-TREND-1 (N = 2412).

	SHIP-TREND-0					SHIP-TREND-1				
	1	2	3	4	5	1	2	3	4	5
	Never	Rarely	Sometimes	Often	Very Often	Never	Rarely	Sometimes	Often	Very Often
Emotional neglect*	1397 (57.9 %)	681 (28.2 %)	146 (6.1 %)	123 (5.1 %)	123 (5.1 %)	1257 (52.1 %)	792 (32.8 %)	168 (7.0 %)	142 (5.9 %)	53 (2.2 %)
Physical neglect*	1490 (61.8 %)	431 (17.9 %)	249 (10.3 %)	83 (3.4 %)	83 (3.4 %)	1352 (56.0 %)	390 (16.2 %)	288 (11.9 %)	154 (6.4 %)	228 (9.5 %)
Physical abuse	2136 (88.5 %)	169 (7.0 %)	72 (3.0 %)	24 (1.0 %)	11 (0.5 %)	2004 (83.1 %)	231 (9.6 %)	109 (4.5 %)	45 (1.9 %)	23 (0.9 %)
Emotional absue	2106 (87.3 %)	178 (7.4 %)	76 (3.1 %)	36 (1.5 %)	16 (0.7 %)	2106 (87.3 %)	161 (6.7 %)	89 (3.7 %)	37 (1.5 %)	19 (0.8 %)
Sexual abuse	2306 (95.6 %)	67 (2.8 %)	31 (1.3 %)	3 (0.1 %)	5 (0.2 %)	2311 (95.8 %)	59 (2.4 %)	28 (1.2 %)	9 (0.4 %)	5 (0.2 %)

* inversed item.

Table 3
Differences between SHIP-TREND-0 and SHIP-TREND-1 in answering the CTS (N = 2412).

			Linear regression		Absolute differences						
	ICC	[95 %-CI]	b	[95 %-CI]	M	SD	10 % Perc.	25 % Perc.	Median	75 % Perc.	90 % Perc.
CTS summary score	0.77	[0.75; 0.79]	0.60	[0.55; 0.64]	0.40	2.19	−2	0	0	1	3
Emotional neglect	0.69	[0.66; 0.71]	0.53	[0.48; 0.58]	−0.07	0.96	−1	0	0	0	1
Physical neglect	0.51	[0.47; 0.55]	0.31	[0.27; 0.35]	−0.22	1.44	−2	−1	0	0	1
Physical abuse	0.78	[0.75; 0.80]	0.52	[0.47; 0.58]	0.10	0.54	0	0	0	0	1
Emotional abuse	0.77	[0.75; 0.79]	0.60	[0.53; 0.67]	0.01	0.56	0	0	0	0	0
Sexual abuse	0.70	[0.68; 0.72]	0.51	[0.38; 0.65]	0.002	0.34	0	0	0	0	0

Linear regressions were adjusted for the interval between SHIP-TREND-0 and SHIP-TREND-1; all $p < 0.001$. M: mean; SD: standard deviation; Perc.: percentile.

%-CI: 0.03; 0.52], $p = 0.029$). Similarly, more severe sexual abuse was associated with more severe current depressive symptoms in women but not in men (sexual abuse * sex: b = 1.18 [95 %-CI: 0.15; 2.21], $p = 0.024$; women: b = 1.67 [95 %-CI: 1.05; 2.29], $p < 0.001$; men: b = 0.49 [95 %-CI: −0.33; 1.30], $p = 0.240$). Additionally, only in women, lower resilience was reported after more severe physical abuse (see Fig. 1B; physical abuse * sex: b = −1.75 [95 %-CI: −3.12; −0.37]; $p = 0.013$; women: b = −1.90 [95 %-CI: −2.93; −0.88], $p < 0.001$; men: b = −0.16 [95 %-CI: −1.08; 0.75], $p = 0.723$) and sexual abuse (sexual abuse * sex: b = −4.04 [95 %-CI: −6.66; −1.42], p = 0.002; women: b = −3.20 [95 %-CI: −4.86; −1.54], $p < 0.001$; men: b = −0.83 [95 %-CI: −1.20; 2.86], p = 0.723). However, results were more inconsistent regarding the lifestyle outcomes: Whereas more severe childhood abuse was associated with a higher probability of lifetime smoking for all CTS items, no association was found with the age at smoking initiation (Table S2). Obesity was associated with more severe physical abuse (OR = 1.23 [95 %-CI: 1.10; 1.38], $p < 0.001$) and sexual abuse (OR = 1.34 [95 %-CI: 1.07; 1.68], $p = 0.012$). Risky alcohol consumption was associated with more severe physical abuse (OR = 1.19 [95 %-CI: 1.01; 1.41], $p = 0.039$). Specifically, this association was found in women but not in men (see Fig. 1C; physical abuse * sex: OR = 1.44 [95 %-CI: 1.05; 1.98], $p = 0.025$; women: OR = 1.43 [95 %-CI: 1.16; 1.76], $p = 0.001$; men: OR = 0.99 [95 %-CI: 0.78; 1.25], $p = 0.908$). Finally, more severe sexual abuse was associated with an increase in WBC (b = 0.01 [95 %-CI: 0.001; 0.03], p = 0.029).

3.3.2. Age of onset

Overall, only one main effect was observed (Table S3): A younger age of onset of emotional abuse was associated with less resilience (b = −0.51 [95 %-CI: −0.98; −0.04], $p = 0.034$). Nevertheless, a younger age of onset of physical abuse was associated with a higher probability of risky alcohol consumption in women but not in men (see Fig. 2A; physical abuse * sex: OR = 0.78 [95 %-CI: 0.63; 0.96], $p = 0.018$; women: OR = 0.83 [95 %-CI: 0.72; 0.97], $p = 0.020$; men: OR = 1.09 [95 %-CI: 0.94; 1.25], $p = 0.259$). In contrast, an older age of onset of emotional abuse was associated with higher hs-CRP levels only in men (see Fig. 2C; emotional abuse * sex: b = −0.03 [95 %-CI: −0.06; −0.001], $p = 0.042$; women: b = −0.01 [95 %-CI: −0.03; 0.01], $p = 0.440$; men: b = 0.02 [95 %-CI: 0.001; 0.05], $p = 0.044$). Finally, differences between men and women were indicated for the association between emotional abuse and the age at smoking initiation (see Fig. 2B; emotional abuse * sex: b = −0.39 [95 %-CI: −0.78; −0.01], $p = 0.047$; women: b = −0.08 [95 %-CI: −0.25; 0.08], $p = 0.323$; men: b = 0.27 [95 %-CI: −0.10; 0.63], $p = 0.147$).

3.3.3. Cumulative exposure

Mainly, compared to one reported age interval, reporting two or three age intervals of emotional abuse was associated with more severe depression (Table S4). In detail, a greater cumulative exposure of emotional abuse associated with a higher probability of lifetime MDD (OR = 1.89 [95 %-CI: 1.04; 3.46], $p = 0.038$), and more severe current depressive symptoms (b = 1.15 [95 %-CI: −0.01; 2.32], $p = 0.052$). Additionally, women compared to men had a lower probability of risky alcohol consumption if physical abuse was reported in only one age interval (see Fig. 3A; physical abuse * sex: OR = 3.92 [95 %-CI: 1.03; 14.94], $p = 0.046$; sex [one age interval]: OR = 0.36 [95 %-CI: 0.14; 0.96], $p = 0.041$). In contrast, women reported an older age at smoking initiation than men if an emotional abuse was reported in more than one age interval (see Fig. 3B; emotional abuse * sex: b = 3.15 [95 %-CI: 0.17; 46.13], $p = 0.039$; sex [two or three age intervals]: b = 2.51 [95 %-CI: −0.28; 5.30], $p = 0.077$). Finally, emotional abuse reported in two or three age intervals was associated with higher fibrinogen levels in women compared to men (see Fig. 3C; emotional abuse * sex: b = 0.05 [95 %-CI: 0.01; 0.09], $p = 0.009$; sex [two or three age intervals]: b = 0.06 [95 %-CI: 0.03; 0.09], $p < 0.001$).

4. Discussion

The present study investigated how the timing of childhood abuse impacts health behavior, inflammation markers, and mental health during adulthood. Focusing on the age of onset and multiple developmental stages by including multiple health characteristics side by side, and further emphasizing sex differences, these analyses added important knowledge to the existing research. Briefly, the strongest main effects were found for the childhood abuse severity, which resembled in men and women. In contrast, the main effects of the age of onset and the cumulative exposure to childhood abuse were focused on mental health outcomes, and sex-specific effects dominated the associations with health behavior and inflammation markers. Thus, our results outline the importance of the timing characteristics of CM and sex differences, particularly in the research of behavioral and somatic CM effects.

Although CM was related to an increased risk of both mental and physical health issues, effect sizes for mental disorders such as

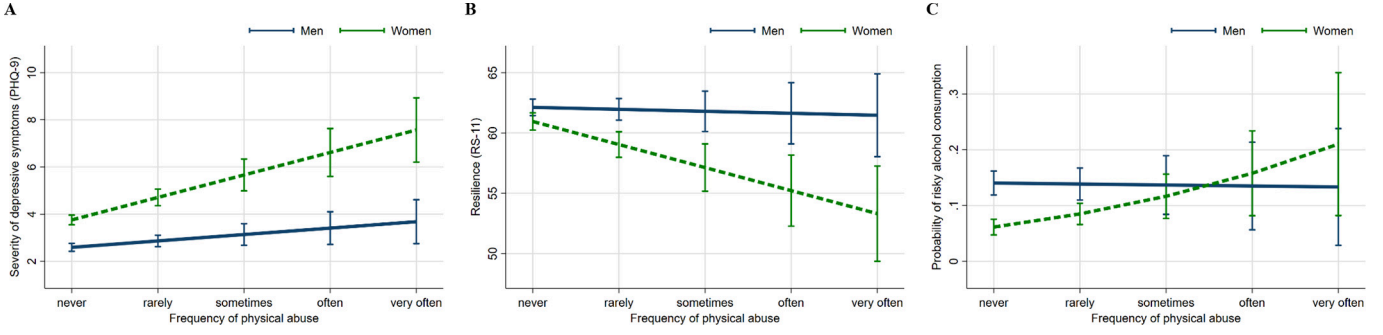

Fig. 1. Sex-stratified associations of the severity of childhood physical abuse in SHIP-TREND-1. (A) Associations with current depressive symptoms. More severe physical abuse was associated with more current depressive symptoms (b = 0.67 [95 %-CI: 0.43; 0.90], $p < 0.001$). This effect was stronger for women compared to men (b = 0.68 [95 %-CI: 0.25; 1.11], p = 0.002). (B) Associations with resilience. More severe physical abuse was associated with less resilience (b = −1.17 [95 %-CI: −1.88; −0.46], p = 0.001). This effect was found in women but not in men (interaction: b = −1.75 [95 %-CI: −3.12; −0.37], p = 0.013). (C) Associations with the probability of risky alcohol consumption. More severe physical abuse was associated with a higher probability of risky alcohol consumption (OR = 1.20 [95 % CI: 1.01; 1.43], $p = 0.034$). This effect was found in women but not in men (OR = 1.47 [95 %-CI: 1.06; 2.04], $p = 0.023$). All analyses were adjusted for age. Mean estimations are presented with 95 %-confidence intervals. For illustrative purposes, margins for the severity were calculated.

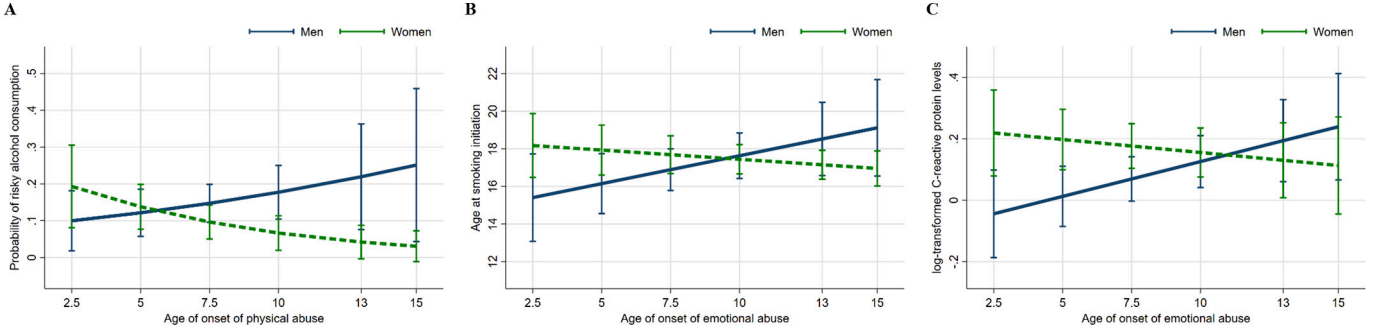

Fig. 2. Sex-stratified associations of the age of onset of childhood abuse in SHIP-TREND-1. (A) Associations of physical abuse with the probability of risky alcohol consumption. Earlier physical abuse was associated with a higher probability of risky alcohol consumption for women (interaction: OR = 0.78 [95 %-CI: 0.63; 0.96], $p = 0.022$; men: OR = 1.09 [95 %-CI: 0.94; 1.25], $p = 0.259$; women: OR = 0.83 [95 %-CI: 0.71; 0.98], $p = 0.030$). (B) Associations of emotional abuse with the age at smoking initiation. The effect direction differed between men and women (interaction: b = −0.39 [95 %-CI: −0.78; −0.01], $p = 0.047$; men: b = 0.27 [95 %-CI: −0.10; 0.63], $p = 0.147$; women: b = −0.08 [95 %-CI: −0.25; 0.08], $p = 0.323$). (C) Associations of emotional abuse with log-transformed C-reactive protein levels. Earlier emotional abuse was associated with lower C-reactive protein levels for men (interaction: b = −0.03 [95 % CI: −0.06; −0.001], $p = 0.042$; men: b = 0.02 [95 %-CI: 0.001; 0.05], $p = 0.044$); women: (b = 0.01 [95 %-CI: −0.03; 0.01], $p = 0.440$). All analyses were adjusted for age; analyses including the C-reactive protein were additionally adjusted for the time of fasting before blood sampling. Mean estimations are presented with 95 %-confidence intervals. For illustrative purposes, margins for the age of onset were calculated in 2.5-year increments.

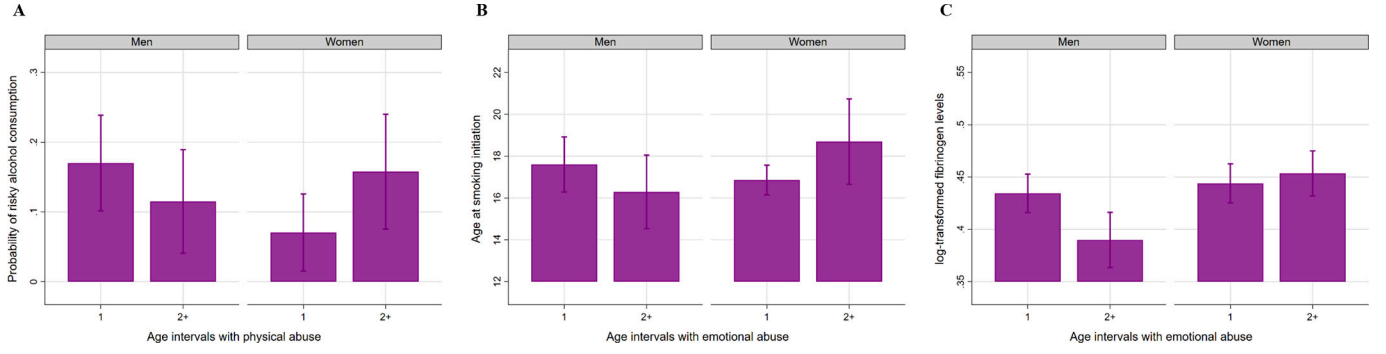

Fig. 3. Sex-stratified associations of the cumulative exposure to childhood abuse in SHIP-TREND-1. (A) Associations of the age intervals with physical abuse and the probability of risky alcohol consumption. The effect directions differed between men and women (interaction: OR = 3.92 [95 %-CI: 1.03; 14.94], $p = 0.046$; men: OR = 0.65 [95 %-CI: 0.26; 1.62], $p = 0.351$; women: OR = 2.63 [95 %-CI: 0.85; 8.21], $p = 0.095$). (B) Associations of the age intervals with emotional abuse and the age at smoking initiation. The effect directions differed between men and women (interaction: b = 3.15 [95 %-CI: 0.17; 6.13], $p = 0.039$; men: b = −0.90 [95 %-CI: −3.21; 1.42], $p = 0.443$; women: b = 1.82 [95 %-CI: −0.43; 4.06], $p = 0.112$). (C) Associations of the age intervals with emotional abuse and log-transformed fibrinogen levels. The effect directions differed between men and women (interaction: b = 0.05 [95 %-CI: 0.01; 0.09], $p = 0.009$; men: b = −0.05 [95 %-CI: −0.09; −0.01], p = 0.022; women: b = 0.01 [95 %-CI: −0.02; 0.04], $p = 0.498$). All analyses were adjusted for age and the age of onset of the respective abuse. Analyses including fibrinogen were additionally adjusted for the time of fasting before blood sampling. Mean estimations are presented with 95 %-confidence intervals. For illustrative purposes, margins for the cumulative exposure were calculated.

depression, anxiety, or substance abuse were consistently larger (Hughes et al., 2017; Klinger-König et al., 2024). Accordingly, our study found strong associations between childhood abuse severity and depression as well as health behavior, irrespective of the type of abuse. Consistent with previous results, resilience was one of the most consistent outcomes (Manly et al., 2001).

Integrating potential sex differences, our study found stronger associations for women between childhood abuse and both more severe depressive symptoms and resilience. Accordingly, higher prevalence rates of depression and anxiety were reported for women whereas higher rates of substance abuse were reported for men (Jacobi et al., 2004; Jacobi et al., 2014). In contrast, Dong et al. (2024) reported stronger associations between physical abuse and MDD in men compared to women with more severe physical maltreatment being associated with a later MDD onset. Our data could support the sex differences neither for lifetime MDD nor for the age of MDD onset. For both men and women, more severe abuse was associated with an earlier MDD onset, irrespective of the type of abuse.

Studies including the age of onset of CM reported a higher risk of internalizing symptoms such as depression and anxiety after an earlier onset of CM but rather externalizing behavior such as substance abuse after a later onset (Kaplow & Widom, 2007). Although the present study could not replicate these overall findings, a later onset of emotional abuse was associated with lower resilience for men and women. Additionally, sex-dependent associations between the age of onset and health behavior during adulthood were found. In detail, women showed a higher probability of alcohol consumption after more severe, longer, and earlier physical abuse. In contrast, men reporting earlier exposure to physical or emotional abuse started smoking earlier in life.

In Europe, physical abuse is more prevalent in men (27 % vs. 12 %) but higher prevalence rates of emotional abuse are reported for women (6 % vs. 13 %) (Moody, Cannings-John, Hood, Kemp, & Robling, 2018). Correspondingly, our data demonstrated higher CRP and fibrinogen levels in women after an earlier onset of and greater cumulative exposure to emotional abuse. Likewise, Ehrlich et al. (2021) reported higher inflammation, including CRP, in girls after early onset and multiple exposure to CM. Danese et al. (2007) also reported higher CRP levels in maltreated adults and were even able to generalize these results to fibrinogen and WBC.

Interestingly, higher CRP levels in children were not only associated with more recent CM but also with stronger internalizing symptoms (Cicchetti et al., 2015). Similarly, more severe sexual abuse was associated with both higher inflammatory markers and worse mental health in the present data. In contrast to the associations between inflammation and abuse timing, however, the associations with abuse severity were sex-independent. According to a review by White and Kaffman (2019), many studies struggled to find sex by CM interactions on mental disorders. If any, CM was more often associated with internalizing disorders such as depression and anxiety in women, but rather externalizing disorders in men (White & Kaffman, 2019).

White and Kaffman (2019) explained that the impact of CM subtypes, developmental stages, and socio-cultural differences might account for study differences. On the other hand, genuine biological sex differences might partly explain the sex-specific associations between childhood abuse and adult health outcomes (White & Kaffman, 2019). Thus, the rather female estrogens were reported to increase cortisol response and sensitivity to stress but were also associated with a more robust HPA axis activity and neuroprotective effects (Heim, Newport, Mletzko, Miller, & Nemeroff, 2008; McEwen, 2010; Oyola & Handa, 2017). Female mice additionally demonstrated impaired glucocorticoid feedback due to lower receptor density and translocation (Bangasser & Valentino, 2014). Integrating a more psychological perspective, different coping strategies were discussed. Higher connectivity between the insula and cingulate cortex combined with greater activation of the medial prefrontal cortex and stronger immune responses during stress in men have been discussed as potential biological markers of these coping differences (Tiwari & Gonzalez, 2018; White & Kaffman, 2019).

Understanding the pathways from CM to adult mental and physical health issues is of prime importance, not only to enable effective secondary and tertiary prevention programs but also to primarily prevent transgenerational effects. Thus, children from early traumatized or mentally diseased mothers demonstrated early neuro-biological changes and had a much higher risk of early CM (Famularo et al., 1994; Yehuda et al., 2016). In our data, earlier abuse was associated with earlier smoking and more risky alcohol consumption in adults in a sex-dependent manner. These findings highlight the need for prevention programs to address behavioral outcomes in a sex-specific manner by providing targeted information and training coping strategies tailored to the different vulnerabilities and needs of men and women. The sex differences demonstrated in the present study, moreover, support known sex differences in health risk factors and reinforce the focus on sex differences in the research of diseases and disease pathways.

For the US, estimations indicate annual costs of US$ 428 billion due to CM (Peterson, Florence, & Klevens, 2018). In Europe, recent estimates pointed to costs of US$ 581 billion per year with estimated annual savings of US$ 105 billion if adverse childhood experiences are reduced by 10 % (Bellis et al., 2019). Thus, effective programs are mandatory to prevent individual burdens and reduce the financial load for society. The present data supported that the timing of CM, including the age of onset and the cumulative exposure across several developmental stages, is an important factor for the long-term effects. Delaying the onset of CM and shortening the duration of these experiences could significantly reduce the long-term health burden. Thus, besides early identification, tailored interventions for specific risk periods should be implemented to minimize exposure during critical developmental phases. Our results demonstrated that these programs should be adaptive to fit the requirements regarding the timing of CM as well as sex differences.

4.1. Limitations

Despite our large sample size, some limitations need to be considered. CM was only measured with five items, one item for each subtype. Our approach to assessing the age of onset and cumulative exposure of CM added additional questions for each abuse item. Age of onset and age intervals were only assessed for childhood abuse but not neglect in our data. Our study demonstrated, however, the excellent acceptance and applicability of our approach to assessing the timing of abuse, and we suggest testing an extension to childhood neglect in upcoming studies. A recent study defined three different neglect classes based on childhood neglect self-reports and reports of protective services (Dubowitz et al., 2019): late neglect with a beginning during adolescence (25 %), chronic neglect (15 %), and limited neglect with the lowest proportions of protective service reports (60 %). This categorization supports the extension of

our extended CTS-version to childhood neglect.

The cumulative exposure was estimated via three multiple-choice age intervals and used as an approximation of duration. Thus, the estimates include a certain blurriness, particularly if the childhood abuse occurred at the transition of these intervals (5/6 years, 10/11 years). Additionally, an experience of childhood abuse >15 years was captured by the individually reported age of onset but not by the age intervals. However, the youngest affirmed age intervals were consistent with the reported age of onset in all cases. <5 % of the participants with childhood abuse reported an age of onset of 15; only one age of onset of 16 was reported for physical abuse.

Our study comprised adults of the general population. Many participants reported no childhood abuse at all. Thus, the sample sizes for the age of onset and age intervals were much smaller, especially for sexual abuse. Due to this reduced target sample, the age of onset was modeled linearly and the cumulative exposure was dichotomized into one vs two or three age intervals. Nevertheless, future studies should include non-linear modulation of the age of onset and a more detailed modulation of duration to investigate the effects more sensitive to developmental stages.

The analyses focused on the most prominent mental health and health behavior outcomes. Nevertheless, our results should be extended to additional outcomes, particularly further mental disorders and physical health issues. Finally, the CM subtypes were investigated separately. As multiple traumatization is likely, however, future studies should also consider the interaction of different subtypes in the analyses of the impact of age of onset on CM.

5. Conclusion

The severity of CM had the strongest impact on both mental health and health behavior outcomes in our study. Regarding age of onset or cumulative exposure, sex-independent associations were found for resilience and depression whereas associations with smoking, alcohol consumption, and inflammation were rather sex-specific. These findings highlight the importance of considering the timing of CM and sex differences when studying its long-term effects.

To deepen the understanding of these associations, more studies on the age of onset of CM are needed, ideally in a longitudinal design. Additionally, our results highlight that it is of utmost importance to increase the focus on sex differences in both risk factors and diseases, including sex-dependent neurobiological and behavioral trajectories.

Finally, our results once again support that sex-specific and subtype-specific prevention programs for CM and therapeutic strategies for patients with CM should be implemented (Tiwari & Gonzalez, 2018; White & Kaffman, 2019). For example, prevention programs should address behavioral outcomes, such as smoking and alcohol consumption, in a sex-specific manner, with targeted strategies for men and women. Moreover, sex-specific resilience-building interventions and coping strategies could support individuals in managing the long-term consequences of CM.

CRediT authorship contribution statement

Johanna Klinger-König: Writing – original draft, Visualization, Software, Methodology, Formal analysis, Conceptualization. **Elischa Krause:** Writing – review & editing, Data curation. **Katharina Wittfeld:** Writing – review & editing, Data curation. **Nele Friedrich:** Writing – review & editing, Resources, Data curation. **Henry Völzke:** Writing – review & editing, Project administration, Funding acquisition. **Hans J. Grabe:** Writing – review & editing, Supervision, Project administration, Methodology, Conceptualization.

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Declaration of competing interest

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.chiabu.2025.107354.

Data availability

The authors do not have permission to share data.

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