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Longitudinal Associations Between Childhood Maltreatment and Allostatic Load Among Midlife and Older Adults: Moderating Role of Perceived Stress and Gender

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Distal experiences of childhood maltreatment have been linked to allostatic load (AL) in middle adulthood. Despite findings that link maltreatment to AL, an indicator of cumulative physiological wear and tear, few studies have considered factors that contribute to changes in AL over time among survivors of maltreatment. Moreover, the moderating process and gender differences remain understudied. Change scores in stress were examined as a moderator of child maltreatment severity and AL over 12 years, and gender differences were tested. Using data from the study of Midlife Development in the United States, a sample of 479 adults was analyzed. Over approximately 12 years, adults participated in four waves of data collection that included surveys, telephone interviews, and fasting blood draws. Using the PROCESS macro, change scores in perceived stress moderated the association between child maltreatment and AL but only for women. Women who experienced a +1 *SD* increase in stress were associated with higher levels of AL. Changes in stress did not moderate the relationship between maltreatment and AL in men. The findings from the study indicate that as levels of childhood maltreatment and change scores in stress increased, so did AL among women. Addressing stress among midlife women would be a particularly fruitful area of prevention research.

Keywords: childhood maltreatment, stress, allostatic load, longitudinal, gender differences

Supplemental materials: https://doi.org/10.1037/trm0000561.supp

Childhood maltreatment is one of the gravest threats to public health. More than one in three adults experienced maltreatment, defined as abuse and neglect in childhood (Fitzgerald et al., 2020). Childhood maltreatment becomes biologically embedded (Miller et al., 2011) and enhances the risk for physiological dysfunction across the life course (Danese et al., 2007; Horan & Widom, 2015). Allostatic load (AL) refers to the cumulative "wear and tear" on the body and encompasses numerous physiological systems such as the cardiovascular and endocrine systems (Danese & McEwen, 2012; McEwen & Seeman, 1999). The cumulative wear and tear of AL can take a variety of forms including (a) physiological responses to chronic, novel stressors; (b) ineffective adaptation to known stressful conditions; (c) prolonged states of arousal (e.g., overresponse to stress); or (d) an inadequate and under response to stress (McEwen & Seeman, 1999), each of which are relevant to childhood maltreatment. Cumulative disadvantage theory and differential exposure and vulnerability models commonly articulate that early adversity, such as maltreatment (i.e., abuse and neglect), leaves adults more vulnerable to experiencing a greater number of stressors, higher levels of psychological symptoms of stress (i.e., feeling overwhelmed), and use more maladaptive coping strategies in response to stress (Hong et al., 2018; Widom et al., 2018).

Stressors and psychological stress (i.e., perceived stress [PS]) differ in the stressors are specific events that potentially induce psychological stress, while psychological stress is often but not the exclusive consequence of stressors. Psychological stress can also be a consequence of stressor pile up where numerous stressors are experienced in close succession or there are no explicit events that rise to be stressful, but the cumulative buildup of subthreshold events can lead to perceiving stress. Middle and older adulthood is an exceptionally complex developmental period characterized by biological, psychological, and social change that may not be evaluated as stressful, but the cumulative impact of change may induce perceptions of stress.

Some posit that the accumulation of PS over the life course increases AL and amplifies the risk for negative health consequences and early mortality (Danese & McEwen, 2012; Guidi et al., 2020; Hwang et al., 2014; Parker et al., 2022; Seeman et al., 1997). However, other theories (e.g., resilience theory) articulate that early adversity is not deterministic of reporting higher levels of PS. In fact, literature documents that sources of resilience among those who have experienced maltreatment (e.g., Horan & Widom, 2015) may offset some consequences of early maltreatment. Despite the theoretical linkage between maltreatment and AL via

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stress, firm conclusions regarding the interrelationships have been hampered in several ways. First, there is a lack of longitudinal research investigating changes in AL over time among those who experienced maltreatment. Known associations highlight that maltreatment is associated with greater AL (e.g., Horan & Widom, 2015), but mechanisms accounting for the change in AL over time remain underdeveloped. Second, surprisingly, few studies have considered the unique effects of maltreatment on AL and instead have focused on heterogeneous definitions of adverse childhood experiences (see Fitzgerald & Gallus, 2024; Misiak et al., 2022 for theoretical and empirical reviews), making definitive conclusions about the unique contributions of maltreatment impossible. Finally, for whom and under what circumstance is maltreatment a risk factor for AL remains largely unanswered and gender may be a discriminating factor (O'Shields & Gibbs, 2021). Possible gender differences may be a function of biological (e.g., menopause; Upchurch et al., 2015) and social factors (e.g., higher levels of stress) that differentiate the interaction of maltreatment and stress on AL over time. In an initial attempt to address these existing limitations, the current study examined the difference scores in PS over 12 years as a moderator of the relationship between maltreatment severity and residualized change in AL over the same 12-year period.

Childhood Maltreatment and AL

Childhood factors have demonstrated notable associations with AL, and research has placed a substantive focus on childhood socioeconomic factors (e.g., Finlay et al., 2022; Graves & Nowakowski, 2017; Misiak et al., 2022). Less studied is the relationship between childhood maltreatment and AL. Decades of theoretical and empirical research have noted that childhood maltreatment takes a physiological toll on children and adolescents (Danese & McEwen, 2012; Grassi-Oliveira et al., 2008; Teicher & Samson, 2016; van der Kolk, 2003) and the physiological consequences persist into adulthood (Horan & Widom, 2015). Although there is relatively little research into the effects of maltreatment on AL, studies have demonstrated that childhood maltreatment has been linked to AL using both prospective (Widom et al., 2018) and retrospective measures of maltreatment (O'Shields et al., 2022), and maltreatment has a documented association with AL in adulthood beyond the contributions of childhood socioeconomic status and other adverse childhood experiences (Horan & Widom, 2015; Widom et al., 2015). There is also evidence that different maltreatment subtypes (e.g., neglect, physical abuse, and sexual abuse) exert nearly identical effects on AL, suggesting that a dose–response effect may be present and that a single form of maltreatment does not appear to be the "driving force" behind the association with AL (Horan & Widom, 2015; Widom et al., 2015). Additionally, gender differences between maltreatment and AL have been noted (O'Shields & Gibbs, 2021) where women who were maltreated experience higher levels of AL compared to men (Horan & Widom, 2015).

Initial attempts have been made to identify moderating processes linking maltreatment to AL, including health behavior, psychopathology, adult socioeconomic status, and social relationships (Barboza Solís et al., 2016; Horan & Widom, 2015); however, studies have seldom considered changes in AL over time. One moderating mechanism likely to link maltreatment to AL is stress (Danese & McEwen, 2012). The association between maltreatment and AL is likely to be amplified by chronic or increasing levels of stress in adulthood, whereas maltreatment may not have a notable impact on changes in AL over time when stress levels are maintained or decline. Further, numerous conceptual models and reviews (e.g., Danese & McEwen, 2012; Ketheesan et al., 2020; McEwen & Seeman, 1999) have suggested that chronic stress increases AL, and the effects may be increasingly pronounced as adults move through the life course. For example, (a) midlife and older adults who experience a greater number of recent stressful life events report higher levels of AL and (b) those with higher levels of psychosocial vulnerability (e.g., social isolation) conferred higher levels of AL (Glei et al., 2007). Likewise, more recent studies have found that higher levels of PS in adulthood are associated with higher levels of AL (Lawrence et al., 2022; Mauss & Jarczok, 2021).

Stress in Midlife Adults

Studying stress processes in midlife adults is particularly useful as the accumulation of lifetime stress increasingly manifests in physiological dysregulation in middle adulthood. Younger adults report the highest levels of stress, midlife adults report moderate levels of stress, and older adults report the lowest levels of stress (Hamarat et al., 2001). While studying younger populations where stress is a more salient phenomenon is a logical conclusion, the physiological effects of stress may not be readily apparent leading to null or inconsistent findings (e.g., Slopen et al., 2012). The relationship between stress and AL is theorized to be cumulative and the effects of maltreatment in childhood and stress in adulthood may therefore not be seen in younger samples. Further evidence for this proposition can be found in the increasing number of health problems attributed to childhood adversity (Ferraro & Kelley-Moore, 2003; McEwen & Seeman, 1999; Umberson et al., 2014) and child abuse specifically (Fitzgerald & Notice, 2023) that occur in midlife adults.

There are numerous possible sources of stress experienced by midlife adults, which is commonly defined as adults between the ages of 40 and 60 (Infurna et al., 2020). Middle adulthood is characterized by biological, individual, family, and social transitions including hormonal changes (e.g., menopause), caring for aging parents, work–life balance, renegotiation of relationships, preparing or transitioning into retirement, launching children, coping with widowhood, and increasing physical limitations (Infurna et al., 2020; Nichols & Davis, 2012). Each of these events and processes has the potential to be appraised as stressful and could amplify the underlying risk for AL. Simultaneously, these same events are also opportunities for meaning making, personal growth that may confer reduced risk for physiological dysfunction. For example, providing care to aging parents could increase stress because of individuals taking on additional responsibilities that require time and energy (e.g., daily stressful events) and are appraised to be stressful (Cohen & McKay, 1985). Children who were abused and neglected by their parents are often caregivers for their aging parents but primarily provide tangible sources of support (e.g., running errands) but not emotional support (Kong & Moorman, 2016). Alternatively, "giving back" to aging parents could be a source of meaning via reciprocation of the care parents had provided during childhood or caring is a way of reconnecting with parents (Infurna et al., 2020). The extent to which adults can successfully navigate the myriad transitions is likely to determine long-term health, while those who are unable to effectively manage such demands are at an enhanced risk for physiological dysfunction and a history of maltreatment is likely to contribute to such processes. In other words, some adults may experience substantial

increases in stress during middle adulthood, while others may maintain or even decrease their levels of stress.

While men and women alike commonly endure significant levels of stress and in midlife, women tend to experience higher levels of stress compared to men (Sacco et al., 2014). A common source of stress for both men and women comes from caregiving for ill and aging family members. There are, however, disproportionate levels of stress experienced by women. Research suggests that (a) women are more likely to provide care to spouses compared to men, and women are more likely to care for aging parents compared to men; (b) when men provide care to aging parents, women are more likely to provide assistance while men provide less help to women caring for her aging parents; and (c) caregiving burden is more likely to result in women passing up promotions, reduce the number of working hours, or leave the workforce entirely leading to an increased likelihood of downstream financial insecurity later in adulthood (Bookman & Kimbrel, 2011). In addition to women facing a greater caregiving burden, they may experience higher levels of stress and greater increases in stress over time via reductions in social support. Studies have found that women in midlife tend to report lower levels of support and more loneliness compared to men (Theeke et al., 2019). Further, women reported fewer benefits from their marriage compared to men (Monin & Clark, 2011). The lack of emotional support, behavioral guidance, advice, empathy, and other psychosocial resources can turn isolated stressful events into ongoing, chronic, and unresolved sources of stress (Thoits, 2011). Other studies have found that women experience greater support but also greater strain (Walen & Lachman, 2000), and the positive effects of support may be offset by the simultaneous experiences of greater stress and strain. Finally, women report higher levels of maltreatment compared to men, which is largely because of stark differences in rates of sexual abuse (Fitzgerald et al., 2020), and such a historical process may leave women more vulnerable to the effects of increases in stress over time.

Present Study

The purpose of the current study was to examine changes in PS (i.e., difference score) as a moderator of childhood maltreatment severity and AL over 12 years (i.e., residualized change) and examine whether the relationship was stronger for women or men. It is expected that changes in PS will moderate the relationship between child maltreatment and AL over the 12-year study period, and the interaction will be significant for women, but not men, will be significant (i.e., three-way interaction of maltreatment, gender, and changes in stress). To best understand the relationship between maltreatment, changes in PS, and AL, several covariates were controlled for. Covariates included sleep problems (McEwen & Seeman, 1999), age, educational achievement, childhood financial situation, the number of medications currently being taken, and the number of chronic health conditions, health behavior, and previous levels of AL (Misiak et al., 2022).

Method

Participants

Data for the current study are from the MIDUS study, which has been continually sponsored by the John D. and Catherine T. MacArthur Foundation since 1995 (https://www.icpsr.umich.edu/web/ICPSR/series/203). The sample was roughly even distributed across gender (54.3% women), and most of the sample was White (94.4%) with African Americans constituting 1.9%, Native Americans were 1%, 0.4% were Asian, 2.1% reported another racial background, and 0.2% reported that they did not know their racial background. The average age of the participants was 52.38 ($SD = 9.95$) at MIDUS 2; for reference, the MIDUS 3 biomarker was completed approximately 16 years after MIDUS 2. Approximately one-fifth of participants (20.7%) reported a high school or General Educational Development education and less, 23.2% reported either an associate degree or an incomplete bachelor's degree, 27.6% reported completion of a 4-year bachelor's degree, 5.2% reported some graduate school, and 17.3% and 6.1% earned a master's and professional degree, respectively. Three-fourths (75.4%) of the sample reported smoking cigarettes frequently at some point in their life and 10.9% reported alcohol problems within the past year. Participants reported an average of 1.91 ($SD = 1.78$) chronic conditions, were taking an average of 5.43 ($SD = 4.60$) medications, and 33.8% reported they were financially better off than others in childhood, 36.7% reported that they were financially the same as others, and 29.4% reported that they were worse off than others.

Procedure

The MIDUS study includes telephone interviews and mailed self-administered questionnaires in 1995–1996 (MIDUS 1), 2004–2006 (MIDUS 2), and 2013–2014 (MIDUS 3). The MIDUS 1 sample comprised individuals from four subgroups: (a) a national random digit dialing (RDD) sample ($n = 3{,}487$), (b) city oversamples in the United States ($n = 757$), (c) siblings of individuals from the RDD sample ($n = 950$), and (d) a national RDD sample of twin pairs ($n = 1{,}914$). MIDUS 2 retained 4,963 participants and MIDUS 3 retained 3,294 individuals. For attritional analyses across the MIDUS study see articles by Radler and colleagues (Radler & Ryff, 2010; Song et al., 2021). Within the MIDUS, the telephone interviews and self-administered questionnaires provide data on psychosocial constructs and physical health variables at MIDUS 1, MIDUS 2, and MIDUS 3. Additional sources of data include daily diary, biomarker, neuroscience, and cognitive subprojects following both MIDUS 2 and MIDUS 3. The study's primary variables were extracted from a sample of adults ($n = 479$) that participated in both the MIDUS 2 biomarker study (2005–2009) and MIDUS 3 biomarker study (2017–2022) and provided data on the study's focal constructs. Additionally, for the twin and sibling subsample, one twin/sibling was randomly excluded to not violate the assumption of independence of residuals. To participate in the biomarker studies, participants had to participate in MIDUS 2 and MIDUS 3. The average time between the MIDUS 2 biomarker and MIDUS 3 biomarker was 12.06 years ($SD = 1.25$), which provides an optimal time frame from which to study changes in stress and AL as the physiological effects of stress accumulate over longer periods of time. All covariates were extracted from the MIDUS surveys (MIDUS 2) except for existing sleep problems and AL, which were measured at the MIDUS 2 biomarker project.

Measures

Childhood Maltreatment

Childhood maltreatment was assessed using the well-validated Childhood Trauma Questionnaire (CTQ; Bernstein et al., 2003).

The CTQ is a 25-item scale that was used to measure childhood abuse and neglect before the age of 18. Items are scored on a 5-point Likert scale ranging from (1) *never* to (5) *very frequently*. The CTQ has been found to have construct validity and criterion-related validity (Bernstein et al., 2003). The emotional neglect subscale and two items on the physical neglect were reverse coded. Childhood maltreatment was operationalized for this study using the total score by summing the emotional, physical, and sexual abuse and physical and emotional neglect scales together. Higher scores reflect greater severity of maltreatment (Cronbach's $\alpha = .92$).

PS

The Perceived Stress Scale is an established measure (PSS; Cohen et al., 1983; Cohen & Williamson, 1988) that is used to measure PS and has been psychometrically validated (Lee, 2012), including validation using the MIDUS data (Taylor, 2015). The MIDUS study used a 10-item version of the PSS where the items were rated on a 5-point Likert scale ranging from (1) *never* to (5) *very often*. The four positively worded items were reverse coded, and the 10 items were summed together. Higher scores are indicative of higher levels of PS. Stress was measured at the MIDUS 2 and MIDUS 3 biomarker studies, and a difference score was created by subtracting PS at MIDUS 3 from MIDUS 2. To represent change over time, a difference score was used rather than an autoregressive relationship. The PSS demonstrated good internal consistency in the sample (Cronbach's $\alpha = .86$ for both time points).

AL

AL scores at the MIDUS 3 biomarker project were calculated based on risk scores in seven physiological system-based methods proffered by Seeman and colleagues (McEwen & Seeman, 1999) and remain the predominant method of capturing AL (e.g., Gruenewald et al., 2012). For each of the 24 biomarkers covering seven physiological systems (sympathetic nervous system, parasympathetic nervous system, cardiovascular, glucose metabolism, lipid/fat metabolism, hypothalamic–pituitary–adrenal axis, and inflammation), those in the top 25% were at risk and received a score of 1, except for six biomarkers for which the low 25% indicated risk and received a score of 1, which is indicative of greater risk and those in the other 75% received a score of 0 (see the online supplemental materials for listing of each of the biomarkers and more detail regarding coding procedures). Next, system scores were calculated by summing risk scores of individual biomarkers within each of the seven physiological systems and dividing the score by the number of biomarkers in the system (i.e., system scores ranged from 0 to 1), which avoids some physiological systems being overweighted in the computation of the overall AL score. Finally, AL scores were calculated by summing the 7 system scores together, creating a possible range of 0 (*no biomarkers were elevated in any system*) to 7 (*every biomarker was elevated in every system*).

Covariates

We included AL, gender, cigarette use, alcohol use, age, educational achievement, sleep problems, number of medications, childhood financial status, and number of chronic health conditions. More detailed information about their measurement can be found in the online supplemental materials.

Data Analysis

The current study employed a multistep analytic method. First, statistical power was examined a priori. A power analysis using G*Power 3.1 was conducted to determine the required sample size needed. Using the following assumptions, a sample size of 395 participants was needed: power = .80, $f^2 = .02$ (small effect size), $\alpha = .05$, 14 predictors, and one interaction. Power was estimated for only one interaction (the three-way interaction term) since the lower-level interactions are not of interest and their interpretation is ambiguous given the presence of the three-way interaction. Descriptive statistics including correlations, means, and standard deviations were calculated stratified across gender. Next, Hayes' PROCESS macro was used (Model 3) to model the moderating effect of changes in PS linking maltreatment to AL. Model 3 tests a three-way interaction (Maltreatment × Changes in PS × Gender). Unstandardized coefficients are reported for ease of interpretation of the interaction.

Results

Power Analysis and Descriptive Statistics

Regarding power, the current study had a sample size of 479, which exceeded the 395 needed to find an interaction as indicated by power analyses. Correlations, means, and standard deviations of the study variables stratified across gender are displayed in Table 1. AL and difference scores in change scores in PS were within acceptable limits for both skewness (AL = 0.54, PS = −0.43) and kurtosis (AL = 1.75, PS = −0.10; Curran et al., 1996), and investigation of residual plots yielded no concern regarding the distribution of the residuals (i.e., residuals were normally distributed).

Primary Analyses

Following the examination of the bivariate statistics and distributional properties of the moderating and outcome variables, Hayes' Macro (Model 3) was utilized to test the moderating role of changes in PS and gender modifying the relationship between childhood maltreatment and AL over a 12-year period (see Table 2). Childhood maltreatment was not associated with AL over time ($b = -.00$, $p = .68$) and neither was the main effect of gender ($b = .07$, $p = .80$). The main effect of difference scores in PS was significantly associated with AL ($b = .16$, $p = .04$) where adults who reported greater increases in PS (i.e., difference score) from MIDUS 2 biomarker to MIDUS 3 biomarker reported greater AL. The interaction term between changes in PS and maltreatment was significant ($b = -.05$, $p = .02$). The maltreatment by gender interaction term was nonsignificant ($b = .00$, $p = .57$), indicating that the relationship between maltreatment and AL did not vary across gender. The gender-by-stress interaction term was significant ($b = -.11$, $p = .01$).

The three-way interaction term of Maltreatment × Changes in Stress × Gender was significant ($b = .03$, $p = .003$). Interpretation of the three-wave interaction indicates that change scores in stress interacted with childhood maltreatment in predicting AL, but the association was only significant among women (see Figure 1). Follow-up analyses included an examination of Johnson–Neyman output (see Table 3), which identifies the specific value when the interaction between the independent variable and moderator becomes

Table 1
Correlations, Means, and Standard Deviations Stratified Across Gender

Variable	1	2	3	Female, *M* (*SD*)
1. Childhood maltreatment	—	.07	.08	38.56 (14.44)
2. Perceived Stress Change Score	−.14*	—	.06	−0.59 (5.87)
3. Allostatic load (MIDUS 3)	.07	−.05	—	1.69 (0.92)
Male, *M* (*SD*)	35.19 (10.57)	−0.26 (5.71)	1.63 (1.01)	

Note. Men are presented below the diagonal and women are presented above the diagonal. MIDUS = Midlife Development in the United States.
* $p < .05$.

statistically significant in the prediction of the dependent variable. When changes in PS were +1 *SD* or greater above the mean in (~6 unit increase in PSS scores over 12 years), the relationship between maltreatment and AL was positive and significant in women ($b = -.013$, $SE = .005$, $p < .01$), while the relationship was not significant in men ($b = -.090$, $SE = .008$, $p = .28$). The relationship between childhood maltreatment and AL did not change at the mean or −1 *SD* values of changes in stress for men or women. Overall, the model accounted for 20.74% of the variance in AL and the three-way interaction term accounted for 1.54% of the variance in AL. Sensitivity analyses were also performed by removing values ± 3 *SD* for all variables (e.g., outliers) and statistical significance and did not change the primary findings, indicating stability of the findings (see the online supplemental materials for more detail). A majority of the sample was between ages 40 and 60 (83.03%), a common operationalization of the midlife stage, we excluded those older and younger as another sensitivity analysis and the three-way interaction remained significant when examining only midlife adults.

Discussion

AL has robust associations with morbidity and mortality (Parker et al., 2022) and identifying precursors of AL among vulnerable populations, such as those who were maltreated, can inform research, clinical practice, and policy. The current study examined the changes (i.e., difference score) in PS over a 12-year period moderating the association between childhood maltreatment and AL across gender. Supporting the study's hypotheses, changes in stress were found to interact with maltreatment in predicting variance in AL over time and the effects were significant for women but not men. Specifically, women who experienced high levels of stress (increases of 6 or more on the PSS scores) resulted in significantly higher levels of AL over time as levels of childhood maltreatment also increased. Surprisingly, the moderating role of changes in PS did not amplify the effects of maltreatment on AL over time among men. It is believed that this is the first longitudinal study utilizing longitudinal assessment of AL among adults with varying experiences of maltreatment, which strengthens existing evidence documenting an association between childhood maltreatment and AL in adulthood that utilize prospective assessments of maltreatment to AL and cross-sectional studies associating retrospective studies of maltreatment with AL (Horan & Widom, 2015; O'Shields & Gibbs, 2021).

Table 2
Regression Model Predicting Residualized Change on Allostatic Load Over a 12-Year Period

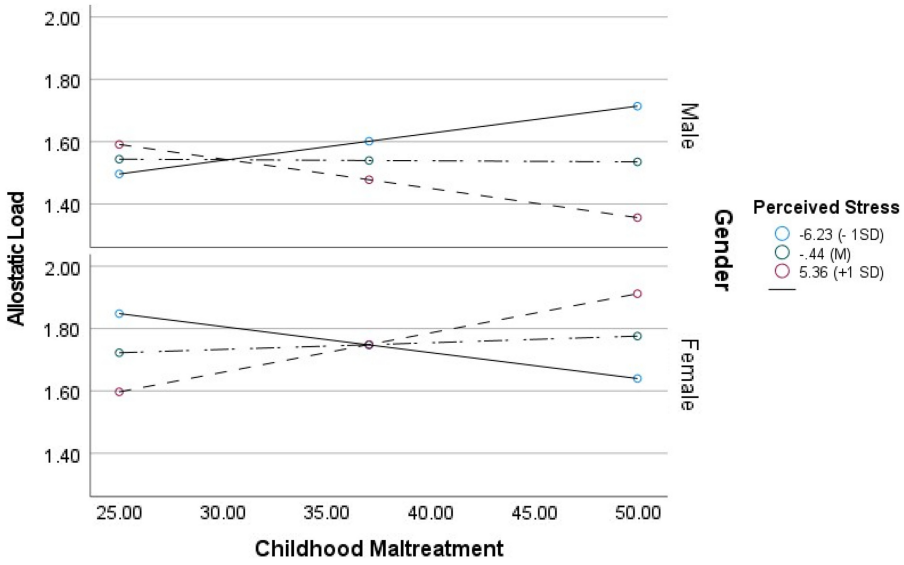
Predictor	*b* (*SE*)	*p*
Maltreatment	.043 (.540)	.70
Stress Change Scores	.162 (.079)	.04
Maltreatment × Stress Change Scores	−.005 (.002)	.02
Gender	.070 (.263)	.80
Maltreatment × Gender	.004 (.007)	.53
Stress Change Scores × Gender	−.114 (.045)	.02
Maltreatment × Stress Change Score × Gender	.033 (.001)	.003
Covariates		
Age	.015 (.032)	.63
Educational achievement	−.030 (.016)	.12
Sleep	.007 (.013)	.61
Number of medications	−.000 (.009)	.98
Cigarette use (ever)	.121 (.090)	.20
Alcohol problem (last year)	.183 (.132)	.16
Child financial situation	.023 (.033)	.49
Chronic health problems	.008 (.030)	.75
M2 AL	.349 (.042)	<.001

Note. Stress is measured as a difference score (MIDUS 3 Stress–MIDUS 2 Stress). M2 = MIDUS 2 biomarker; AL = allostatic load; MIDUS = Midlife Development in the United States.

The primary contribution of the study was documenting that changes in PS amplified the relationship between maltreatment and AL over time. McEwen (2012) noted that maltreatment and adversity are associated with decreased volume of critical brain structures including those associated with regulation (e.g., prefrontal cortex), fear appraisal (e.g., amygdala), and memory (e.g., hippocampus), which have significant implications of threat appraisal, learning to manage stress ability, and emotional regulation (D'Andrea et al., 2012). Further, the brain structures of children who were maltreated in childhood bear a striking resemblance to those of adults who were maltreated, suggesting that early maltreatment potentiates altered neuroanatomy and physiological responses that can persist into adulthood (Danese & McEwen, 2012) and ongoing and increasing stress amplifies the effects of early maltreatment and increase AL over time (Juster et al., 2010). The findings from the current study supported the study's hypotheses that changes in PS would interact with maltreatment in predicting change in AL over time. Women who experienced the combination of childhood maltreatment and greater increases in stress over time result in higher levels of AL. This is consistent with previous literature, which found differential patterns of the association between childhood maltreatment and AL across gender (O'Shields & Gibbs, 2021). It could be argued that the found gender differences could be attributed to women reporting higher levels of childhood maltreatment compared to men and PS having a significantly stronger association with AL in women compared to men (Mauss & Jarczok, 2021). Thus, the effects of childhood maltreatment on AL at high levels of PS are amplified in women because of a stronger link between PS and AL. This, however, does not explain

Figure 1

Interaction Plot Depicting the Three-Way Interaction Between Childhood Maltreatment, Changes in Perceived Stress, and Gender



how, while insignificant, the interaction was in the opposite direction for males. Gender differences have been proposed in social determinants of health (Golinelli et al., 2021; Shin & Park, 2023; Wang et al., 2023) women often play a more central role in adulthood, including women who were maltreated in childhood (Wuest et al., 2010). The more central role women play leaves them vulnerable to additional stress not experienced by men (Walen & Lachman, 2000), and over extended periods of time the heightened levels of stress influence physiology (McEwen & Seeman, 1999). The higher levels of stress because of the more central role of women can manifest in both sibling relationships (e.g., being the primary caregiver of aging parents; Bookman & Kimbrel, 2011) and in romantic relationships (Monin & Clark, 2011), and some of the benefits that men experience may come at a cost to their women (i.e., women providing more support than men; Fitzgerald et al., 2020). When men are more distressed or engaging in health-hindering behavior, they may receive more guidance or support from women in their lives such as sisters and wives (Fitzgerald et al., 2020; Thoits, 2011), while women do not obtain the same benefit from the men in their lives (i.e., brothers, husbands).

Table 3

Output of the Three-Way Interaction Between Childhood Maltreatment, Changes in Perceived Stress, and Gender Predicting Allostatic Load

Perceived stress change scores	Gender	*b*	*SE*	*p*
−6.23 (−1 *SD*)	Male	.009	.008	.28
−6.23 (−1 *SD*)	Female	−.008	.006	.13
−0.44 (*M*)	Male	−.000	.006	.95
−0.44 (*M*)	Female	.002	.004	.60
5.35 (+1 *SD*)	Male	−.009	.008	.28
5.35 (+1 *SD*)	Female	.012	.005	<.01

Note. Positive scores of the Perceived Stress Change Score indicate increases in stress over a 12-year period.

Limitations and Future Directions

Despite several strengths, the current study is not without limitations. First, the current study took a difference score of PS and was unable to determine the nature of changes (e.g., rates of change) in stress over the study period. Using growth curve analysis to examine the rates of change may be a particularly fruitful area of future inquiry. Another notable limitation is that reports of maltreatment were retrospective. While research has utilized both prospective and retrospective reports of maltreatment when studying AL, and there are very few false positives (Hardt & Rutter, 2004), having documented maltreatment increases the validity of findings. Future research should examine prospective reports of documented abuse and neglect and AL, which is particularly notable as correlations are notably stronger among substantiated/documented cases of maltreatment (Horan & Widom, 2015; Widom et al., 2015) compared to retrospective reports. The study focused on the experience of stress but did not consider how stress was coped with, which will be a key factor in understanding the sequelae of stress over time among those who experience maltreatment. Another notable limitation is that the current study was predominantly White, middle class, and well-educated adults and has limited generalizability to other populations. To address health disparities, replicated results in other populations will be a critical next step. Finally, we used assessments of subjective experiences of stress rather than objective stressful events or levels of stress associated with specific events (e.g., divorce and caring for aging parents), and future research should operationalize stress differently.

Conclusion

Longitudinal evidence from the current study underscores the importance of reducing stress, particularly among midlife women, as it is a noted risk factor for greater AL among women who experienced an increasing amount of maltreatment. Consistent with

theories on AL, cumulative stress over the life course is associated with greater AL over time. Intervention targeting appraisals of stressors may be particularly helpful points of prevention and intervention among midlife women to reduce levels of PS. Prevention and intervention efforts may want to target both reducing stressful life events among those who were maltreated, especially women, but also appraisals of stressors and responses to stressors (e.g., coping).

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