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Adverse childhood experiences, health perception, and the role of shared familial factors in adult twins

Sheeva Mostoufi, MS¹, Eric Strachan, PhD², Laura Chopko, BA², Annemarie Succop, BA², Beatrice Martinez, BA³, Sandra M. Ahumada, BA⁴, and Niloofar Afari, PhD^{5,3}

¹San Diego State University/University of California, San Diego Joint Doctoral Program in Clinical Psychology, 5500 Campanile Dr., San Diego, CA 92182-4611, USA

²Department of Psychiatry & Behavioral Sciences, University of Washington, 1959 NE Pacific Street, Box 356560, Seattle, WA 98195-6560, USA

³Department of Psychiatry, University of California, San Diego, 9500 Gilman Drive, 0737, La Jolla, CA 92093, USA

⁴Institute of Child Development, University of Minnesota, Twin Cities, 75 East River Road, Minneapolis, MN 55455, USA

⁵VA Center of Excellence for Stress and Mental Health and VA San Diego Healthcare System, 3350 La Jolla Village Drive, San Diego, CA 92161, USA

Abstract

Objectives—To examine the relationship between adverse childhood experiences (ACE) and health perception in adulthood, and to explore the contribution of shared familial factors to these associations.

Methods—Data were collected from 180 female twins (90 pairs) from the community-based University of Washington Twin Registry. Participants completed questionnaires including the modified ACE Questionnaire, Traumatic Life Events Questionnaire, McGill Pain Questionnaire-Short Form, and the SF-36. Mixed effects linear regression modeling investigated the effects of ACE on indices of health perception controlling for correlated twin data. Additional models examined the associations while controlling for the experience of physical and/or sexual abuse in childhood; within-twin pair models that inherently adjust for familial factors explored shared familial influences.

Results—After controlling for relevant demographic variables, more ACE was associated with worse perceptions of general health ($p = 0.01$) and vitality ($p = 0.05$) on the SF-36. After

Correspondence to: Sheeva Mostoufi, M.S., Department of Psychiatry, University of California, San Diego, 9500 Gilman Drive, 0737, La Jolla, CA 92093; smostouf@ucsd.edu.

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controlling for childhood physical and/or sexual abuse, the relationship between ACE and general health remained significant ($p = .01$) while vitality was no longer significant. None of the associations remained significant after accounting for the influence of familial factors.

Conclusions—These results support previous findings on the negative link between ACE and perceived health in adulthood. The detrimental effects of ACE on vitality may be accounted for by the experience of childhood physical and/or sexual abuse. Shared familial factors might play a partial role in the relationship between ACE and health perception. Future research should further investigate the genetic and environmental mechanisms that may explain this relationship.

Keywords

Adverse childhood experiences; Child abuse; Genetics; Health perception; Physical health; Twins

INTRODUCTION

Adverse childhood experiences (ACE) can influence physical and psychological well-being in adulthood. Previous research has found a link between physical, emotional, or sexual abuse in childhood and a range of mental and physical health outcomes in adulthood including depression (Gibb, Chelminski, & Zimmerman, 2007), anxiety disorders (Spinoven et al., 2010), severe psychiatric symptoms (Bryer, Nelson, Miller, & Krol, 1987; Janssen et al., 2004), and physical symptoms such as pain (Bonomi, Cannon, Anderson, Rivara, & Thompson, 2008). Women who have been both physically and sexually abused during childhood show poorer perceived health, engage in more risky health behaviors, and have difficulty with mental and physical functioning resulting in higher average annual healthcare costs compared to controls (Bonomi, et al., 2008; Walker et al., 1999).

Adverse events such as separation or death of a parent, living with family members who used illicit drugs, and family mental illness or incarceration also have been associated with poorer physical health (Dube et al., 2001; Felitti et al., 1998; McBeth, Macfarlane, Benjamin, Morris, & Silman, 1999). The seminal study by Felitti and colleagues (Felitti, et al., 1998) found that there was a graded relationship between the number of adverse childhood events and negative health behavior and conditions in adulthood. For example, persons with 4 or more categories of adverse events were 1.5-4 times more likely than those without adverse events to have a number of health conditions including diabetes, heart disease, cancers, stroke, and emphysema. However, the associations were not reported separately for adverse event categories, making it difficult to determine which adverse events had the strongest relationship with negative health outcomes. Others have linked these adverse experiences to increased likelihood of engaging in risky health behaviors such as illicit drug use and risky sexual behaviors (Ramiro, Madrid, & Brown, 2010). Family dysfunction has also been associated with an earlier onset of psychiatric disorders (Benjet, Borges, & Medina-Mora, 2010) and increased likelihood of attempting suicide (Ramiro, et al., 2010).

However, the relationship between childhood adversity other than physical and sexual abuse and perceptions of health has not been thoroughly examined. This line of investigation is important because perceptions of health are associated with changes in functioning ability

over time (Idler & Kasl, 1995). There is evidence that psychological maltreatment is associated with greater self-reported concern with physical health (Hager & Runtz, 2012) but little work has examined the breadth of adverse events we are proposing. In addition, no study to date has examined potential mechanisms by which ACE and health perception in adulthood might be related. Recent studies have found a role for specific genes in the relationship between child maltreatment and a range of difficulties in adulthood (Alemany et al., 2011; Brown & Harris, 2008; Fergusson, Boden, Horwood, Miller, & Kennedy, 2011). Therefore, the role of familial factors (i.e. shared genetics and common family environment) in the link between ACE and health perception, is worthy of investigation.

In lieu of experimental designs that may be impossible or unethical, co-twin studies constitute a natural experiment that can help to distinguish potentially causal relationships from relationships that stem from shared familial influences including genetic and common environmental factors (Kendler & Campbell, 2009; McGue, Osler, & Christensen, 2010). For example, if the association between two traits is not causal but results from familial factors that affect both traits, we would expect little association between the two traits in a within-twin pair design that naturally adjusts for the confounding effects of familial factors. Alternately, if the association between two traits is causal, then we would expect a robust association even within closely matched twin pairs.

Therefore, the goals of this study were 2-fold: a) to examine the relationship between ACE other than childhood physical and/or sexual abuse and health perception in adulthood; and b) to explore the contribution of shared familial factors to these associations in within-twin pair analyses.

METHODS

Participants and procedures

Study participants were 198 female twins (99 twin pairs) recruited from the community-based University of Washington Twin Registry (Afari et al., 2006). Recruitment occurred from 2006-2010. Potential participants were randomly selected from the Registry and included both pain-free twin pairs and pairs discordant for medically unexplained pain. Because the study focused on medically unexplained pain, potential participants were excluded if they had any medical conditions that could explain their pain (e.g., cancer, autoimmune diseases) or that might affect data collection (e.g., uncontrolled endocrine and allergy conditions, cardiopulmonary problems, sleep disorders). Potential participants also were excluded if they were current smokers, tested positive for drugs of abuse during the study visit, had body mass index (BMI) of < 20 or > 30 kg/m², were pregnant or planning to become pregnant during the course of the study, had an amputated limb, or were completely blind or deaf. All of the participants lived in Washington State or Oregon.

Once enrolled, the twins completed a comprehensive battery of questionnaires at home before attending a 2-day study visit at the University of Washington, which typically occurred within 2 weeks of completing the battery of questionnaires. A complete description of the study and participant inclusion and exclusion criteria is available elsewhere (Afari et al., 2011). Written informed consent was obtained from all participants and the study was

approved by the Institutional Review Boards at the University of Washington and University of California, San Diego.

Measures

Demographic information included age, race and ethnicity, education level, and marital status. A modified version of the *Adverse Childhood Experiences* (ACE) Questionnaire was used to assess the presence or absence of childhood exposure to 5 categories of adverse experiences including psychological abuse, parental substance abuse, parental mental illness, criminal behavior in the household, and violent treatment of mother or stepmother (Felitti, et al., 1998). The original ACE questionnaire included 2 categories, one each on childhood physical abuse and childhood sexual abuse. However, these 2 categories were removed from the modified ACE questionnaire because a more comprehensive measure of physical and sexual abuse was used as described below. Modified versions of the ACE questionnaire have been used previously to examine chosen ACEs of interest (Cabrera, Hoge, Bliese, Castro, & Messer, 2007). For the present study, modified ACE questionnaire scores ranged from 0 (not having experienced any of the events) to 5 (having experienced an event in each category).

The *Traumatic Life Events Questionnaire* (TLEQ), which assesses for 21 potentially traumatic events using behaviorally descriptive terms, was used to determine whether participants had experienced either child physical and/or sexual abuse (Kubany et al., 2000). The items specifically inquired whether the perpetrator was a stranger, friend/acquaintance, relative, or intimate partner, and if the abuse occurred after the age of 13. The TLEQ uses behaviorally descriptive terms for each of the items. For example, the childhood physical abuse item avoids emotionally charged terms such as “abuse,” by asking, “Were you physically punished in a way that resulted in bruises, burns, cuts, or broken bones.” A total of 3 items assessing for sexual abuse and 1 item assessing physical abuse before the age of 18 were used from the TLEQ to create 2 binary variables, one for childhood sexual abuse and one for childhood physical abuse. These 2 variables were combined to indicate the presence or absence of any childhood physical and/or sexual abuse, and included as a covariate in regression analyses. The TLEQ exhibits adequate to excellent temporal stability, and the questionnaire format has been shown to yield similar disclosure rates of trauma history as a structured-interview format (Kubany, et al., 2000). It is noteworthy that across four test-retest studies, temporal stability was found to be strongest for childhood physical abuse (kappas = .63 to .91) and childhood sexual abuse by someone more than five years older (kappas = .70 to .90), two of the 4 items used in our study. The content validity of items assessed is considered one of the greatest strengths of the TLEQ (Kubany, et al., 2000).

The visual analog scale of the *McGill Pain Questionnaire-Short Form* (MPQ-SF) was used to assess current pain intensity with a 100mm line (Melzack, 1975). Because some of the participants were recruited to have medically unexplained pain, the MPQ-SF pain intensity rating was used as a covariate in all analyses to control for the potential role of pain intensity.

Health perception was assessed using the *Short Form Health Survey* (SF-36), a widely used measure of health functioning with high reliability and acceptable convergent validity (Ware & Sherbourne, 1992). The SF-36 results in the following 8 domains: physical functioning, role physical, bodily pain, general health, vitality (i.e., fatigue/energy), role emotional, and mental health. T-scores range from 0-100 with higher scores indicating greater levels of functioning.

Statistical analyses

Descriptive statistics were calculated using means and standard deviations for continuous variables and frequencies for categorical variables. Mixed effects linear regression models, which account for the non-independence of twins within a pair, were used to examine the overall effect of the modified ACE questionnaire as the independent variable on each of the 8 SF-36 domains as the dependent variables. To determine the unique association between ACE and each of the 8 SF-36 domains, a second set of mixed effect linear regression models controlled for having the presence or absence of childhood physical and/or sexual abuse. All analyses controlled for age, pain severity, Hispanic ethnicity, race, and education.

For those SF-36 domains with significant overall associations, a final set of analyses examined the within-twin pair associations of ACE and the SF-36 domains. Within-twin pair analyses are inherently adjusted for familial factors such as genetic and common environmental influences (Begg & Parides, 2003). These analyses are based on the assumption that monozygotic (MZ) pairs share 100% of their DNA, dizygotic (DZ) pairs share, on average, 50% of their DNA, and twin pairs are typically raised in the same household sharing a common family environment. Therefore, within-twin pair associations control for familial factors (i.e., both genetic and common environmental factors) that may influence the relationship between 2 traits. If within-twin pair associations are attenuated compared to the overall effect, we can conclude that familial factors contribute to these associations. Alternately, a within-twin pair association that is not attenuated compared to the overall effect provides evidence that familial factors do not play a prime role in the association between ACE and health functioning in adulthood. Therefore, familial confounding is suggested when the within-twin pair regression coefficients are smaller than the overall coefficients or are non-significant.

To calculate within-twin pair effects, mixed effects linear regression models were fit such that the exposure of interest was the deviation of the individual ACE score from the pair-level average ACE score (Begg & Parides, 2003). Within-twin pair effects were estimated only for associations that were significant in the overall analyses. The within-twin pair models also adjusted for age, pain severity, Hispanic ethnicity, race, education, and the presence or absence of childhood physical and/or sexual abuse. In order to provide an estimate of the magnitude of the familial effect, intraclass correlations (ICC) for each of the within-twin pair models were calculated based on the random effects parameters. The level of statistical significance was set at 0.05. Data were analyzed using SPSS 16.0 (IBM, Chicago, IL).

RESULTS

Complete ACE questionnaire data were available from 180 twins (90 twin pairs). Of those, 65 pairs were monozygotic. Participants were all female with an average age of 29 years ($SD = 10$); 86% identified themselves as White, 7.8% were Hispanic, 59% had never been married, and 50% had a bachelor's degree or greater.

Overall, 28% of the individuals endorsed having experienced only adverse events captured by the ACE questionnaire, 8% endorsed only childhood physical and/or sexual abuse, and 10% endorsed experiencing both ACE and childhood physical and/or sexual abuse. In terms of pair-wise concordant responses (i.e., both twins in a pair responded either yes or no to the category), twin pairs' responses were least concordant for the psychological abuse (86%), parental mental illness (84%), and childhood sexual abuse (83%) and were most concordant for criminal behavior in the household (100%), childhood physical abuse (94%), mother in the household being treated violently (93%), and parental substance abuse (91%).

Table 1 presents the characteristics of all individual twins for the key study variables. The average VAS pain rating was 20 ($SD = 19$) on a 0-100 scale. In terms of ACE categories, exposure to parental mental illness (25%) was the most frequently reported adverse event and exposure to criminal behavior (2%) was the least frequently reported adverse event. On average, individuals reported experiencing 0.7 ($SD = 1.1$) adverse events (other than physical and/or sexual abuse) in their childhood. Childhood physical abuse and childhood sexual abuse were reported by 7% and 16% of the sample, respectively. The SF-36 domain scores ranged from an average of 57.9 for vitality (i.e., fatigue/energy) to an average of 96.5 for physical functioning. These scores are consistent with average to above average functioning as would be expected in a relatively young and healthy sample. In addition, these SF-36 scores were similar to the norms for the US general population (Ware, Snow, Kosinski, & Gandek, 1993).

Table 2 presents the 3 sets of regression coefficient estimates for the association of ACE scores with SF-36 domains, first controlling for age, pain severity, Hispanic ethnicity, race, education, then controlling for the demographic variables as well as childhood physical and/or sexual abuse, and finally controlling for familial factors in the within-twin pair analyses. Initial findings indicated that higher ACE scores were significantly related to worse general health perception ($p = .01$) and vitality, i.e., more fatigue ($p = .04$); the association with mental health approached significance ($p = .07$). After also controlling for childhood physical and/or sexual abuse, the relationship between ACE and general health remained significant ($p = .01$) while the effect on vitality was no longer significant, suggesting that the link between ACE and vitality may be partially confounded by the co-occurrence of childhood physical and/or sexual abuse with other ACE. After controlling for familial factors in the within-twin pair analyses, the associations between ACE and SF-36 domains were no longer significant. The near-complete attenuation of the regression coefficient estimates in the within-twin pair analyses along with ICCs ranging from 0.31 to 0.48 suggest that familial factors may play a partial role in the relationship between ACE and perceptions of health in adulthood.

DISCUSSION

To our knowledge, this is the first study to explore the potential confounding effects of familial factors in the link between ACE and health perception in adulthood. In a sample of twins, we found that those who reported more adverse childhood events had worse perceptions of general health and vitality. However, when accounting for childhood physical and/or sexual abuse in these associations, the link with vitality was no longer significant, suggesting that the association between ACE and vitality could be confounded by the experience of childhood physical and/or sexual abuse. In contrast, the association between ACE and general health perception remained significant even after accounting for childhood physical and/or sexual abuse, suggesting that general health perception may be influenced by a wider range of adverse childhood experiences beyond childhood physical and/or sexual abuse. Further accounting for the confounding role of familial factors in the within-twin pair analyses eliminated all of these effects, highlighting the potential role of familial factors in the relationship between ACE and health perception. Although preliminary, these findings suggest that ACE and health perception partly may be linked through a common set of experiences in the family environment or the same set of genetic factors may predispose an individual to the experience of adverse events as well as poor health perception.

Whereas previous studies have examined the relationship between ACE and various health conditions (Bonomi, et al., 2008; Bryer, et al., 1987; Gibb, et al., 2007; Janssen, et al., 2004; McBeth, et al., 1999; Spinhoven, et al., 2010; Walker, et al., 1999), we extended this work by examining perceptions of health as a function of ACE beyond physical and sexual abuse. Therefore, our findings build on previous literature by suggesting an association between a range of childhood adverse experiences beyond childhood sexual or physical abuse, and a poorer perception of general health functioning in adulthood. Future research should continue to distinguish between various adverse events in childhood to determine their unique relationship to health perception. For instance, emotional neglect, a specific type of child maltreatment has been uniquely associated with depressive disorder, dysthymia, and social phobia (Spinhoven, et al., 2010). This research can be expanded to further explore how other adverse experiences in childhood are related to different types of physical and mental health. Better differentiating these specific relationships between adverse experiences in childhood and health may also offer healthcare providers clues on how to properly intervene.

Our findings, especially with regards to the familial confounding, suggest that the relationship between adverse events in childhood and health perception and functioning in adulthood is likely multifactorial. Additional research is needed to specifically examine whether shared genetics or specific environmental mechanisms make a larger contribution to the link between ACE and perceptions of health. For example, health behaviors such as sleep habits (Bader, Schafer, Schenkel, Nissen, & Schwander, 2007; Scharf et al., 2011) and coping style (Leitenberg, Gibson, & Novy, 2004; Vosvick et al., 2002) can impact both ACE and general health and may play a mediating role in their relationship. It is possible that the variability in adverse experiences is related to variability in health behaviors, which ultimately contributes to poorer perception of health functioning. Further, a gene by environment interaction has been found in the association between child maltreatment and a

number of mental health conditions in adulthood (Alemany, et al., 2011; Brown & Harris, 2008; Fergusson, et al., 2011), suggesting that the study of gene by environment interactions might help to identify specific genetic and environmental factors that mediate the relationship of ACE and perceived health in adulthood.

Our findings also may have important implications for encouraging more thorough assessment in clinical settings for a wider range of adverse childhood experiences. Primary care providers are in a unique position to see patients across the life span, and there is evidence that women in particular are more likely to talk about maltreatment issues when in the context of medical care (Walker, Torkelson, Katon, & Koss, 1993). These findings may provide further support and elaboration of programs such as the Safe Environment for Every Kid (SEEK) model which aim to improve the attitudes and competence of child healthcare professionals in addressing risk factors for child maltreatment in primary care settings (Dubowitz, Feigelman, Lane, & Kim, 2009).

The primary strength of this study was the use of twins to investigate familial confounding in the relationship between ACE and health perception. Another strength was the focus on ACE beyond physical and sexual abuse. Nonetheless, there are some notable limitations. First, our sample was relatively young and healthy which may have limited the range of health perception difficulties. Second, because the majority of the sample was monozygotic, we did not have adequate power with the small number of dizygotic twin pairs to thoroughly examine the unique contribution of shared genetics independent of shared familial environment. Future research should aim to further delineate the unique role of genetics in this relationship and examine specific shared environmental factors that may contribute to both adverse experiences and health perception. Third, we relied on self-report measures that were based primarily on retrospective recall of adverse childhood experiences, rendering it difficult to determine the time order of adverse events and physical and sexual abuse experiences. Additionally, our findings are based on a limited number of questions from the TLEQ and a modified version of the ACE questionnaire. Therefore, future studies should use structured interviews, case file information, and more comprehensive assessments to confirm the association of adverse childhood experiences and health in adulthood. Fourth, given our relatively small sample size, it is recommended that future studies use larger sample sizes with more power and diversity to replicate these relationships. Finally, we did not examine the role that twins' shared memories may have played in the relationship between ACE and health perception. Depending on the extent of shared memories between co-twins, our findings may be an underestimate of the shared familial contribution to ACE and health perception. Examining twins reared apart would be useful in examining the role of shared memories on these associations.

In sum, we found even after accounting for demographics and childhood physical and/or sexual abuse, increased self-reported adverse events in childhood were related to poorer health functioning in adulthood. We also found that this association may be partially due to familial factors. Further examination of mechanisms that may explain the relationship between ACE and health is warranted to provide important information on how to better prevent poor health perception in adulthood in individuals who have experienced substantial adversity in their childhood.

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Abbreviations

ACE	Adverse childhood experiences
MPQ-SF	McGill Pain Questionnaire-Short Form

SF-36	Short Form Health Survey-36
TLEQ	Traumatic Life Events Questionnaire

Table 1
Characteristics of individual twins on all key study variables

Individual Twins (N = 180)	
Pain Severity Rating, Mean (SD)	20(19)
Adverse Child Events (ACE) Categories, %	
Psychological abuse	17
Parental substance abuse	21
Parental mental illness	25
Criminal behavior in household	2
Mother treated violently	6
ACE, Mean (SD)	0.7(1.1)
Traumatic Life Events Questionnaire Categories, %	
Childhood physical abuse	7
Childhood sexual abuse	16
SF-36 Domains, Mean (SD)	
Physical Functioning	96.5 (9.2)
Role Physical	95.4(15.7)
Bodily Pain	77.5 (17.2)
General Health	82.4(14.0)
Vitality	57.9(17.4)
Role Emotional	89.4 (24.3)
Mental Health	75.5(14.4)
Social Functioning	91.7(16.1)

Table 2

Regression coefficient estimates and *p*-values for 3 sets of analyses examining the association of adverse childhood experiences with SF-36 domains

SF-36 Domains	Overall models controlling for demographic variables ^a (<i>N</i> = 180)		Overall models controlling for demographics and childhood physical and/or sexual abuse ^b (<i>N</i> = 180)		Within-twin pair models ^c (<i>N</i> = 90)	
	Estimate (95% CI)	<i>p</i> -value	Estimate (95% CI)	<i>p</i> -value	Estimate (95% CI)	<i>p</i> -value ICC
Physical Functioning	.271 (-1.04, 1.58)	.68	.386 (-1.03, 1.60)	.57		
Role Physical	-1.00 (-3.33, 1.32)	.39	-1.11 (-3.50, 1.28)	.36		
Bodily Pain	-1.28 (-3.13, .573)	.18	-1.20 (-3.12, .731)	.22		
General Health	-2.67 (-4.72, -.612)	.01	-2.75 (-4.86, -.647)	.01	1.56 (-3.02, 6.15)	.50
Vitality	-2.76 (-5.33, -.186)	.04	-2.14 (-4.70, .424)	.10	.754 (-4.15, 5.66)	.76
Role Emotional	-1.86 (-5.40, 1.40)	.30	-.965 (-4.57, 2.64)	.60		
Mental Health	-2.08 (-4.30, .157)	.07	-2.07 (-4.34, .21)	.07	-1.56 (-6.12, 2.99)	.50
Social Functioning	-.999 (-3.33, 1.33)	.40	-.284 (-2.64, 2.08)	.81		
ICC						.42

^aMixed effects regression models controlling for age, pain severity, Hispanic ethnicity, race, education, and the correlated nature of twin data.

^bMixed effects regression models controlling for age, pain severity, Hispanic ethnicity, race, education, childhood physical and/or sexual abuse, and the correlated nature of twin data.

^cWithin-twin pair mixed effects regression models, controlling for age, pain severity, Hispanic ethnicity, race, education, childhood physical and/or sexual abuse, and familial confounding.

CI = confidence interval; ICC = intraclass correlation.