Published in final edited form as:
Biol Res Nurs. 2012 April ; 14(2): 115–123. doi:10.1177/1099800411398479.

Telomere Shortening in Formerly Abused and Never Abused Women

Janice Humphreys, PhD[1], **Elissa S. Epel, PhD**[2], **Bruce A. Cooper, PhD**[3], **Jue Lin, PhD**[4], **Elizabeth H. Blackburn, PhD**[4], and **Kathryn A. Lee, PhD**[1]

[1]Department of Family Health Care Nursing, School of Nursing, University of California, San Francisco

[2]Department of Psychiatry, UCSF

[3]Office of Research, School of Nursing, University of California, San Francisco

[4]Department of Biochemistry and Biophysics, University of California, San Francisco

Abstract

Recent studies suggest that chronic psychological stress may accelerate aging at the cellular level. Telomeres are protective components that stabilize the ends of chromosomes and modulate cellular aging. Women exposed to intimate partner violence (IPV) experience chronic stress and report worse health. The purpose of this exploratory study was to examine telomeric DNA length in women who have experienced chronic stress related to IPV. We hypothesized that IPV exposure would be associated with shorter telomere length. The investigation used a cross-sectional design to study telomere length in women with a history of IPV exposure and control women who reported no prior exposure to IPV. Advertisements and public notices were used to recruit a convenience sample of healthy women. Mean leukocyte telomere length was measured in DNA samples from peripheral blood mononuclear cells (PBMCs) by a quantitative polymerase chain reaction assay (qPCR). Telomere length was significantly shorter in the 61 formerly abused women compared to the 41 controls ($t = 2.4$, $p = .02$). Length of time in the abusive relationship and having children were associated with telomere length after controlling for age and body mass index ($F_{(2,99)} = 10.23$, $p < .001$). Numerous studies suggest that women who experience IPV have poorer overall health. It is often presumed that the stress of IPV may be causing greater morbidity. Findings from this descriptive study suggest a link between IPV exposure, duration of IPV-related stress, and telomere length molecular mechanisms that regulate cellular aging.

Keywords

intimate partner violence; telomere length; chronic stress

Intimate partner violence (IPV) refers to physical or sexual violence (with the use of physical force) or the threat of such violence or psychological/emotional abuse and/or coercive tactics when there has been prior physical and/or sexual violence between persons who are partners or former partners (Saltzman, Fanslow, McMahon, & Shelley, 1999). In North American population-based surveys, between 8% and 14% of women of all ages have reported physical assault in the previous year by a husband, boyfriend, or ex-partner; the

Corresponding Author: Janice Humphreys, PhD, RN, NP, FAAN UCSF School of Nursing Department of Family Health Care Nursing 2 Koret Way, Box 0606 San Francisco, CA 94143-0606 Janice.humphreys@nursing.ucsf.edu Office = (415) 476-4432 Fax = (415) 753-2161.
EEpel@lppi.ucsf.edu Bruce.cooper@nursing.ucsf.edu Jue.lin@ucsf.edu Elizabeth.blackburn@ucsf.edu Kathryn.lee@nursing.ucsf.edu

lifetime prevalence of IPV was between 25% and 30% (Breiding, Black, & Ryan, 2008; Thompson et al., 2006). IPV can occur in all kinds of intimate relationships; however, IPV is most often committed by men against women (Breiding et al., 2008). Although severity can vary, the type of IPV that is particularly problematic involves a pattern of coercive control that is deliberate, repetitive, and prolonged (Humphreys & Campbell, 2011).

The World Health Organization noted that 20% to 50% of women who experienced IPV reported that it resulted in physical injury and deleterious health effects (e.g., broken bones, problems walking, memory loss, suicidal ideation) lasting long after the violence ended and that IPV interferes with even simple activities of daily life (Garcia-Moreno, Heise, Jansen, Ellsberg, & Watts, 2005). Abused women often experience symptoms that appear unrelated to IPV and have an unspecified origin (Katon, Sullivan, & Walker, 2001). Health care providers often characterize the complex array of symptoms as manifestations of stress and find these women difficult to diagnose and treat (Sutherland, Sullivan, & Bybee, 2001). When asked directly, women often attribute their health problems to IPV (Queen, Nurse, Brackley, & Williams, 2009).

IPV of all types is a potent source of chronic stress (Woods et al., 2005). Physical abuse is one of the most common causes of injury in women (Rand, 1997); however, research has also documented the negative effects of psychological and emotional IPV on women's health (Arias & Pape, 1999; Coker, Smith, Bethea, King, & McKeown, 2000; Dutton, Goodman, & Bennett, 1999; Wijma, Samelius, Wingren, & Wijma, 2007). In qualitative studies abused women have described experiencing IPV as being “crushed in a corner” or “smothered under a big black cloud” and “stripped of dignity” (Wuest & Merritt-Gray, 2001, p. 283).

One physiological response to chronic stress such as IPV appears to be changes in telomere length, which may be a useful marker of biological age and thus a predictor of early morbidity and early mortality across many health problems. Telomeres shorten in response to chronic stress, and a critical minimum telomere length triggers cell senescence. Chronic stress in female mice has been associated with telomere shortening (Kotrschal, Ilmonen, & Penn, 2007). It is postulated that excess accumulation of senescent cells may attenuate normal function throughout the body, leading to chronic inflammation and age-related diseases. Duration of caregiving for a child with a chronic condition has been associated with shorter telomere length and dampened telomerase activity in young healthy women (Epel et al., 2004). This association has also been documented in elderly dementia caregivers (Damjanovic et al., 2007) and individuals with major depression (Simon et al., 2006). Recently Tyrka and colleagues (2009) evaluated the effects of childhood adversity in a community-based sample of 31 men and women with and without a history of childhood maltreatment. Participants reporting a history of maltreatment had significantly shorter telomeres than those who did not report such maltreatment ($t = 2.4$, $p = .03$). This finding was not due to effects of age, gender, smoking, body mass index (BMI), or other demographic factors known to be associated with shortened telomeres. Likewise, Kananen and colleagues (2010) also reported that childhood adversity was associated with telomere shortening in adults.

In this study, we examined telomere length in peripheral blood mononuclear cells (PBMC) in women who had been exposed to IPV as a chronic form of stress, compared to women who reported no history of IPV. Given that age and obesity (Kim et al., 2009; Valdes et al., 2005) may influence telomere length, we also included these two variables in exploring the association between IPV exposure and telomere length.

Methods

Sample

For this exploratory study, we recruited a convenience sample of women who reported a history of IPV (n = 66) and women who reported no history of IPV (n = 46) in the western United States using newspaper and web-based advertisements and other public notices. Advertisements stated that the purpose of the study was to better understand how stressful events, including partner abuse, may affect women even after the abuse has ended. Women contacted the study coordinator to learn more about the study. Participants had to be at least 18 years of age, nonsmokers, pre-menopausal, in good health, and English-speaking. We assessed health status and smoking history using a detailed questionnaire and determined initial IPV history over the phone using the Abuse Assessment Screen (McFarlane, Parker, Soeken, & Bullock, 1992). Formerly abused women had to have a history of experiencing IPV as an adult (≥ 16 years of age) but also to have been out of the abusive relationship for at least 1 year. Never abused women had no experience with IPV. We further explained study procedures to eligible participants. If women were still interested, we met them in a research office where we confirmed their initial telephone screenings and conducted further screening for IPV status using the Women's Experience with Battering (WEB) scale, a 10-item measure that operationalizes the experiences of abused women (Smith, Earp, & DeVellis, 1995). For the purposes of this screening, we only asked women whether or not they had experienced any of the 10 items. We initially assigned women with an IPV history and controls to each group based on this measure. Eligible women gave verbal consent, completed questionnaires, were measured for height and weight, and had a single venipuncture blood sample taken.

The University of California, San Francisco, Committee on Human Research approved this study. Trained members of the research team carried out all procedures, with particular concern for IPV-associated risks and the rights of study participants. All data collection occurred in a private research office. Upon completion of questionnaires, we gave each participant a community resource card that provided 24-hr domestic violence hotlines and other IPV contact information.

Measurements

Intimate partner violence—The Revised Conflict Tactics Scale (CTS2) is a 72-item measure that asks participants to indicate which tactics they and their partners use to resolve a conflict and how often they use those tactics (Straus, Hamby, & Warren, 2003). In the present study, we used only items that assessed women's experiences (i.e., partner's behavior toward them and injuries suffered as a result). These 39 items were scored into four conflict resolution subscales: psychological aggression, sexual coercion, physical assaults, and injury experience. The CTS2 has been demonstrated to be a valid and reliable measure of IPV in multiple community-based studies (Straus et al., 2003). We scored the prevalence for type of conflict as the percentage of women who reported at least one instance of that type of IPV during the last year of her relationship. We also used these data to make the final determination of a participant's status as either a formerly abused or never abused woman.

Depression—The Beck Depression Inventory, 2nd edition (BDI-II), is a 21-item self-report instrument for measuring the severity of depression (Beck, Steer, & Brown, 1996). Participants choose the alternative that best describes how they felt during the past 2 weeks. Items are rated from 0 to 3, and a total score can range from 0 to 63, with higher scores reflecting increased depressive severity. The BDI-II is widely used to estimate severity of depression and has strong psychometric properties in the general population (Segal, Coolidge, Cahill, & O'Riley, 2008).

Perceived stress—The 10-item version of the Perceived Stress Scale is a valid and reliable measure of the degree to which participants find their lives to be unpredictable, uncontrollable, and overwhelming. For each item, participants indicate on a 5-point Likert scale how often in the previous month ("never" to "very often") they experienced various thoughts and feelings. Examples of items include, "How often have you felt that you were unable to control the important things in your life?" and, "How often have you felt that you were on top of things?" The questions are of a general nature and hence relatively free of content specific to any clinical population. Investigators have used it extensively in ethnically diverse adult samples. Scores range from 0 to 40. Research has shown that pre-menopausal women and women of lower socioeconomic status (SES) have higher mean scores compared to men (Cohen, Kamarck, & Mermelstein, 1983).

Sources of stress other than IPV—The Wheaton Social Stress Inventory is a 51-item checklist of social, work, relationship and financial difficulties that may cause stress other than that due to IPV (Turner, Wheaton, & Lloyd, 1995). Participants indicate to what extent various situations are ongoing in their lives. All endorsed items are summed with possible scores ranging from 0 to 51.

Demographic data—We collected demographic data using a questionnaire that has been used in previous women's health research to assess the following variables: age, financial status, health status, employment status, educational background, marital and parenthood status, routine medication use, age at the time of the abusive relationship, length of the relationship, and smoking history.

We measured height in centimeters and weight in kilograms and used these to calculate BMI using the following formula: weight (kg) / height (cm^2).

Telomere length—Mean telomere length is measured as the ratio of telomeric product/ single copy gene (T/S) obtained using a quantitative polymerase chain reaction (PCR). The longer the telomeres are in each sample, the more PCR products will be generated in PCR reactions using primers specific for the telomeric DNA.

We adapted the telomere length measurement assay in this study from the published original method by Cawthon (2002; Lin et al., 2010). The telomere thermal cycling profile consisted of the following steps: Cycling for T (telomic) PCR: denature at 96°C for 1 s, anneal/extend at 54°C for 60 s, with fluorescence data collection, 30 cycles. Cycling for S (single copy gene) PCR: denature at 95°C for 15 s, anneal at 58°C for 1 s, extend at 72°C for 20 s, 8 cycles; followed by denature at 96°C for 1 s, anneal at 58°C for 1 s, extend at 72°C for 20 s, hold at 83°C for 5 s with data collection, 35 cycles.

The primers for telomere PCR were *tel1b* [5'-CGGTTT$(GTTTGG)_5$GTT-3'] used at a final concentration of 100nM and *tel2b* [5'-GGCTTG$(CCTTAC)_5$CCT-3'] used at a final concentration of 900nM. The primers for the single-copy gene (human beta-globin) PCR were *hbg1* [5'-GCTTCTGACACAACTGTGTTCACTAGC-3'] used at a final concentration of 300nM and *hbg2* [5'-CACCAACTTCATCCACGTTCACC-3'] used at a final concentration of 700nM. The final reaction mix contained 20mM Tris-HCl, pH 8.4; 50mM KCl; 200 mM each dNTP; 1% DMSO; 0.4× Syber Green I; 22ng E. coli DNA per reaction; 0.4 units of Platinum Taq DNA polymerase (Invitrogen Inc.) per 11 μL reaction; 0.5–10 ng of genomic DNA. We included tubes containing 26, 8.75, 2.9, 0.97, 0.324 and 0.108 ng of a reference DNA (from Hela cancer cells) in each PCR run so that we could determine the quantity of targeted templates in each sample relative to the reference DNA sample by the standard curve method. We ran each concentration of the reference DNA as quadruplets and samples as triplicates.

To control for interassay variability, we included eight control DNA samples from cancer cell lines (including 293T, H1299, UMUC3, and UMUC3 cells infected with a lentiviral construct containing the telomerase RNA gene to extend telomeres, harvested at various population doublings after infection) in each run. In each batch, we divided the T/S ratio of each control DNA by the average T/S for the same DNA from 10 runs to get a normalizing factor. This was done for all eight samples, and we used the average normalizing factor for all eight samples to correct DNA samples to get the final T/S ratio. We measured the T/S ratio for each sample twice. When the duplicate T/S value and the initial value varied by more than 7%, we ran the sample a third time and reported the two closest values. Typically, about 15% of samples need to be assayed a third time. The interassay coefficient of variation for telomere length measurement was 3.5% for this study.

Statistical Analysis

We analyzed data using SPSS for Windows (version 15.0) software (SPSS, Inc.). We used descriptive statistics to present the demographic characteristics of the sample. We tested group differences in telomere length with an independent samples *t*-test and used Pearson correlations to examine mean telomere length and associations with age, BMI, depression, perceived stress measures, and IPV parameters.

Given the small sample size for this exploratory study, there was insufficient statistical power to examine all potential predictors in a single multiple regression analysis. Therefore, we categorized all potential predictors listed in Tables 1, 2, and 3 into three subsets (age and BMI, demographic variables, and variables associated with IPV) for independent analyses. Following recommendations of Hosmer and Lemeshow (2000), we entered variables other than age and BMI that met initial criteria of a Pearson correlation ≥ 0.20 with telomere length into a simultaneous regression model and removed variables with a p value ≥ 0.10 from the regression model. We examined remaining predictors to determine if any p value exceeded 0.10 and removed those one at a time until all variables remaining in the model had a p value ≤ 0.10. While controlling for age and BMI, we followed this conservative approach for each subset of variables. We entered variables meeting the criterion from each subset simultaneously into a final regression model and evaluated them using the same procedure until the final model contained only those variables with p values ≤ 0.10.

Results

Table 1 lists detailed demographic characteristics for the 112 women in this sample. As shown, formerly abused women were similar to women who never experienced IPV on current employment status but had lower income. Formerly abused women were older and less educated, were more likely to have children, and were more likely to be Black, Latino or multiracial compared to women who reported no past experience with IPV. Formerly abused women also reported more lifetime trauma exposures and were more likely to have a history of smoking cigarettes. BMI for formerly abused women was significantly higher than BMI for women who had never experienced IPV. Only two women in the never-abused group were categorized as obese, whereas 32 of the 66 (49%) formerly abused women had a BMI > 30 (Division of Nutrition, Physical Activity and Obesity, National Center for Chronic Disease Prevention and Health Promotion, 2009).

As shown in Table 2, formerly abused women reported varied exposure to IPV. While all of the women in this group reported psychological aggression, 80% also reported severe physical assaults, 58% severe physical injuries, and 50% severe sexual coercion.

Table 3 summarizes the results for the two groups on the Beck Depression Inventory, two global measures of stress, and mean telomere length. The formerly abused women and never

abused women were significantly different on each of these measures. Formerly abused women were more depressed and reported more stress on both the Perceived Stress Scale and the Wheaton Social Stress Inventory compared to women who had never been abused.

We could not obtain blood samples on 10 participants (5 formerly abused women and 5 never abused women). Therefore, telomere-length results are for 102 women. The mean telomere length for formerly abused women was significantly shorter than for women who had never been abused.

Table 4 summarizes salient variables correlated with telomere length (correlation coefficients ≥ 0.20). As expected from the literature, age and BMI were associated with telomere length. Thus, we controlled for age and BMI in our models

The final model contained only two variables: having children and length of time abused. Although age and BMI were weakly associated with telomere length when tested in a model by themselves, they offered no contribution to the model once having children and length of time in the abusive relationship were included. Thus, we removed age and BMI from the model. As is shown in Table 5, having children accounted for 6.7% of the unique variance in telomere length and length of time of abuse in years accounted for 3.7% of the unique variance. Having children and length of time abused jointly predicted 17% of the variance in telomere length ($R^2 = .171$, $F_{(2,99)} = 10.23$, $p < .001$).

One unexpected finding was that age and BMI were not significant predictors of telomere length in this sample. The group difference in age was statistically significant but clinically less meaningful than the group difference in BMI. Given the large group difference in BMI and known relationship between BMI and telomere length, we tested whether BMI might mediate or moderate the relationship between abuse history and telomere length. Mediation and moderation analyses are best examined through path or structural equation models. We tested this simple mediation model using Mplus (Muthén & Muthén, 2009). Two conditions for mediation were met: abuse history predicted telomere length, and abuse history was associated with BMI. However, there was no association between telomere length and BMI in the model. Even with BMI in the model, abuse history still predicted telomere length and the effect was not reduced. Furthermore, the indirect effect of abuse history on telomere length must be significant for mediation to exist. In these data, the indirect effect was trivial and not significant. Therefore, there was no mediating effect of BMI in the association between abuse history and telomere length in this sample.

However, group assignment in this convenience sample of formerly abused and never-abused women had a moderator effect. In other words, BMI predicted telomere length differently depending on abuse history. BMI was not associated with telomere length in women who had never been abused ($r = -.02$), however BMI was inversely related to telomere length in the women with a history of IPV ($r = -.187$), and the difference between their two slopes was significant ($t = -2.04$, $p = .045$), as shown in Figure 1.

In addition to age and BMI, race/ethnicity has also been associated with telomere length, with Blacks and Hispanics having shorter telomeres and telomere length that declines more rapidly with age (Roux et al., 2009). Given that the formerly abused and never abused women in this study differed significantly based on self-reported ethnicity, we conducted additional analysis to determine to what extent, if any, ethnicity was driving the differences in telomere length independent from IPV. We examined the possible differences in mean telomere length between ethnicity categories, using ANCOVA analysis to control for age and BMI. The effect of ethnicity was not significant. There was weak evidence for a difference between Whites and Asians (not controlling for age and BMI), but even that

effect was less significant with the covariates. There was no evidence at all that Latinos or Blacks differed from Whites or any other groups on telomere length.

Discussion

Formerly abused women in our sample had significantly shorter mean telomere length than women who had never been abused. In addition, we found that being a mother and length of time in the abusive relationship were the best predictors of telomere length.

There is considerable literature on the increased burden for women associated with mothering and caregiving (Berg & Woods, 2009; Donelan, Falik, & DesRoches, 2001), and being a mother of a chronically ill child is associated with shortened telomere length (Epel et al., 2004). However, given abused women's documented concerns about the effects of IPV on their children (Haight, Shim, Linn, & Swinford, 2007; Kelly, 2009; Ulrich, 1991), the chronic stress of mothering may take a unique toll in this population. Additional research is needed to explore this relationship.

In this study, length of time in the abusive relationship, regardless of the type of IPV experienced, was also a significant predictor of telomere length. Data amassed over the past 20 years demonstrate the physical and psychological health consequences that result from all types of IPV. Our findings indicate that the type of IPV is less important than how long the abuse persists. If, as has been suggested (Gerbert et al., 2000; McFarlane, Groff, Brien, & Watson, 2006), assessment for IPV itself is a type of intervention that shortens the duration of abuse, our findings lend support for the need for universal IPV screening.

An unexpected finding in our study was that BMI predicted telomere length differently depending on abuse history. BMI was not associated with telomere length among women who had never been abused; however BMI was inversely related to telomere length in the women with a history of IPV. There is a growing body of empirical evidence that prior exposure to abuse in childhood is associated with adult obesity (Bentley & Widom, 2009; D'Argenio et al., 2009; Pederson & Wilson, 2009). Given the ever increasing and appropriate concern about overweight and obesity in North America, the relationship between exposure to abuse and elevated BMI needs further study.

In addition to advocating for universal assessment for IPV, based on our findings we offer several implications for nurses and nurse scientists. First, nurses who provide care to currently and formerly abused women now have additional evidence that women's complex array of symptoms may be related to IPV and are indeed manifestations of the effects of this stress at a cellular level. The finding that telomere-length shortening was associated with motherhood and length of time in the abusive relationship even after the abuse had ended provides evidence for the need to pay particular attention to abused mothers and women who have experienced extended periods of IPV regardless of the type of abuse. Second, recent research by Puterman and colleagues (2010) offers evidence for the buffering effects of vigorous physical activity on telomere length among women experiencing high stress. Nurses who care for women experiencing IPV and women experiencing other sources of stress should consider offering advice about the benefits of physical activity as a means of preventing the cellular changes found in our study. Finally, telomere length offers great promise as a relatively new and objective marker of physical and psychological stress. With telomere length as an objective measure, and in light of the buffering effects of physical exercise, we are intrigued about the possible benefits that other well documented health-promoting behaviors, such as adequate sleep and good nutrition, might also have on formerly abused women's health. However, future research will be required to address these questions.

In this initial study with a nonrandom sample and a cross-sectional design, results cannot be generalized to all women with a history of abuse. Furthermore, considering the highly polymorphic nature of telomere length in humans, only a longitudinal analysis can definitively tell whether experience of IPV accelerates loss of telomere length in PBMCs. Furthermore, another important issue that future investigations need to address is the use of PBMCs as the source for telomere length measurement. Since PBMCs consist of a mixed population of cell types (including T and B lymphocytes, NK cells and monocytes), it is possible the short telomeres found in PBMCs could be due to the shortening of telomeres in one or more types of cells or the increased relative proportion of certain types of cells with short telomeres. Understanding whether IPV has an impact on the composition of PBMCs and whether IPV is correlated with short telomeres in each cell type would provide more information.

Another important area requiring further study is the question of the relationship between race/ethnicity and telomere length. While there was only weak evidence of a difference between Whites and Asians (broadly defined) in our sample (when not controlling for age and BMI), others have reported that Blacks and Hispanics have shorter telomeres and more rapid decline in telomere length with age (Roux et al., 2009). The relationship between ethnicity/race and telomere length deserves further examination.

Thus, there is a need for larger and longitudinal studies of formerly and never-abused women who are randomly selected from a broader community of women across the United States. Nevertheless, our findings provide evidence of the sustained negative effects of IPV for women even when they are no longer in the abusive relationship. Furthermore, the moderating effect of abuse on BMI in the subsample of abused women is intriguing. Both of these findings lend support for the routine screening for IPV in all health care settings.

In summary, an extensive body of literature describes immense physical and psychological health consequences resulting from IPV. It is often presumed that the stress of IPV may be causing greater morbidity; however, the mechanism of action has remained elusive. These preliminary findings suggest a link between telomere length and duration of IPV exposure as well as the chronic stress of parenting children within an environment of IPV exposure. Findings provide further evidence for why the well-documented effects of IPV continue to affect women's health even after the abuse has ended.

Acknowledgments

We wish to acknowledge Candace Burton, Ifeyinwa Asiodu, and Ashley Schumacher for their invaluable assistance and to thank the brave women who participated in this study. All of the authors participated in the analysis of the data and in the preparation of the manuscript. None of the authors has a conflict of interest. Funding for the study was obtained by Dr. Humphreys in the form of a University of California, San Francisco, Clinical and Translational Science Institute's Strategic Opportunities Support Award. However, the funding source had no involvement in any part of the conduct of the research. This study was approved by the University of California, San Francisco Committee on Human Research.

References

Arias I, Pape KT. Psychological abuse: Implications for adjustment and commitment to leave violent partners. Violence and Victims. 1999; 14(1):55–67. [PubMed: 10397626]

Beck, AT.; Steer, RA.; Brown, GK. BDI-II: Beck Depression Inventory Manual. 2nd ed.. Psychological Corporation; San Antonio: 1996.

Bentley T, Widom CS. A 30-year follow-up of the effects of child abuse and neglect on obesity in adulthood. Obesity. 2009; 17(10):1900–1905. [PubMed: 19478789]

Berg JA, Woods NF. Global women's health: A spotlight on caregiving. Nursing Clinics of North America. 2009; 44(3):375–384. [PubMed: 19683098]

Breiding MJ, Black MC, Ryan GW. Prevalence and risk factors of intimate partner violence in eighteen U.S. states/territories, 2005. American Journal of Preventive Medicine. 2008; 34(2):112–118. [PubMed: 18201640]

Cawthon RM. Telomere measurement by quantitative PCR. Nucleic Acids Research. 2002; 30(10):e47. [PubMed: 12000852]

Cohen S, Kamarck T, Mermelstein R. A global measure of perceived stress. Journal of Health and Social Behavior. 1983; 24(4):385–396. [PubMed: 6668417]

Coker AL, Smith PH, Bethea L, King MR, McKeown RE. Physical health consequences of physical and psychological intimate partner violence. Archives of Family Medicine. 2000; 9(5):451–457. [PubMed: 10810951]

Damjanovic AK, Yang Y, Glaser R, Kiecolt-Glaser JK, Nguyen H, Laskowski B, Weng NP. Accelerated telomere erosion is associated with a declining immune function of caregivers of Alzheimer's disease patients. Journal of Immunology. 2007; 179(6):4249–4254.

D'Argenio A, Mazzi C, Pecchioli L, Di Lorenzo G, Siracusano A, Troisi A. Early trauma and adult obesity: Is psychological dysfunction the mediating mechanism? Physiology & Behavior. 2009; 98(5):543–546. [PubMed: 19733190]

Division of Nutrition. Physical Activity and Obesity. National Center for Chronic Disease Prevention and Health Promotion. About BMI for adults. 2009. Retrieved August 7, 2009, from the Centers for Disease Control and Prevention website at http://www.cdc.gov/healthyweight/assessing/bmi/adult_bmi/index.html

Donelan K, Falik M, DesRoches CM. Caregiving: Challenges and implications for women's health. Women's Health Issues. 2001; 11(3):185–200. [PubMed: 11336860]

Dutton MA, Goodman LA, Bennett L. Court-involved battered women's responses to violence: The role of psychological, physical, and sexual abuse. Violence and Victims. 1999; 14(1):89–104. [PubMed: 10397628]

Epel ES, Blackburn EH, Lin J, Dhabhar FS, Adler NE, Morrow JD, Cawthon RM. Accelerated telomere shortening in response to life stress. Proceedings of the National Academy of Sciences of the United States of America. 2004; 101(49):17312–17315. [PubMed: 15574496]

Garcia-Moreno C, Heise L, Jansen HA, Ellsberg M, Watts C. Public health. violence against women. Science. 2005; 310(5752):1282–1283. [PubMed: 16311321]

Gerbert B, Moe J, Caspers N, Salber P, Feldman M, Herzig K, Bronstone A. Simplifying physicians' response to domestic violence. Western Journal of Medicine. 2000; 172(5):329–331. [PubMed: 10832426]

Haight WL, Shim WS, Linn LM, Swinford L. Mothers' strategies for protecting children from batterers: The perspectives of battered women involved in child protective services. Child Welfare. 2007; 86(4):41–62. [PubMed: 17953327]

Hosmer, DW.; Lemeshow, S. Applied logistic regression. 2nd ed.. Wiley; New York: 2000.

Humphreys, J.; Campbell, JC., editors. Family violence and nursing practice. 2nd ed.. Springer Publishing Company; New York: 2011.

Kananen L, Surakka I, Pirkola S, Suvisaari J, Lonnqvist J, Peltonen L, Hovatta I. Childhood adversities are associated with shorter telomere length at adult age both in individuals with an anxiety disorder and controls. PloS One. 2010; 5(5):e10826. [PubMed: 20520834]

Katon W, Sullivan M, Walker E. Medical symptoms without identified pathology: Relationship to psychiatric disorders, childhood. Annals of Internal Medicine. 2001; 134(9):917. [PubMed: 11346329]

Kelly UA. Integrating intersectionality and biomedicine in health disparities research. ANS: Advances in Nursing Science. 2009; 32(2):E42–56. [PubMed: 19461221]

Kim S, Parks CG, DeRoo LA, Chen H, Taylor JA, Cawthon RM, Sandler DP. Obesity and weight gain in adulthood and telomere length. Cancer Epidemiology, Biomarkers & Prevention. 2009; 18(3): 816–820.

Kotrschal A, Ilmonen P, Penn DJ. Stress impacts telomere dynamics. Biology Letters. 2007; 3(2):128–130. [PubMed: 17264051]

Lin J, Epel E, Cheon J, Kroenke C, Sinclair E, Bigos M, Blackburn E. Analyses and comparisons of telomerase activity and telomere length in human T and B cells: Insights for epidemiology of

telomere maintenance. Journal of Immunological Methods. 2010; 352(1–2):71–80. [PubMed: 19837074]

McFarlane J, Parker B, Soeken K, Bullock L. Assessing for abuse during pregnancy. Severity and frequency of injuries and associated entry into prenatal care. JAMA. 1992; 267(23):3176–3178. [PubMed: 1593739]

McFarlane JM, Groff JY, Brien JA, Watson K. Secondary prevention of intimate partner violence: A randomized controlled. Nursing Research. 2006; 55(1):52–61. [PubMed: 16439929]

Muthén, LK.; Muthén, BO. Mplus. Muthén & Muthén; Los Angeles: 2009.

Pederson CL, Wilson JF. Childhood emotional neglect related to posttraumatic stress disorder symptoms and body mass index in adult women. Psychological Reports. 2009; 105(1):111–126. [PubMed: 19810438]

Puterman E, Lin J, Blackburn E, O'Donovan A, Adler N, Epel E. The power of exercise: Buffering the effect of chronic stress on telomere length. PloS One. 2010; 5(5):e10837. [PubMed: 20520771]

Queen J, Nurse A, Brackley MH, Williams GB. Being emotionally abused: A phenomenological study of adult women's experiences of emotionally abusive intimate partner relationships. Issues in Mental Health Nursing. 2009; 30(4):237–245. [PubMed: 19363728]

Rand, MR. Violence-related injuries treated in hospital emergency department. Bureau of Justice statistics special report. U.S. Department of Justice; Washington, DC: 1997.

Roux AV, Ranjit N, Jenny NS, Shea S, Cushman M, Fitzpatrick A, Seeman T. Race/ethnicity and telomere length in the multi-ethnic study of atherosclerosis. Aging Cell. 2009; 8(3):251–257. [PubMed: 19302371]

Saltzman, LE.; Fanslow, JL.; McMahon, PM.; Shelley, GA. Intimate partner violence surveillance: Uniform definitions and recommended data elements. Centers for Disease Control and Prevention; Atlanta: 1999.

Segal DL, Coolidge FL, Cahill BS, O'Riley AA. Psychometric properties of the Beck Depression Inventory II (BDI-II) among community-dwelling older adults. Behavior Modification. 2008; 32(1):3–20. [PubMed: 18096969]

Simon NM, Smoller JW, McNamara KL, Maser RS, Zalta AK, Pollack MH, Wong KK. Telomere shortening and mood disorders: Preliminary support for a chronic stress model of accelerated aging. Biological Psychiatry. 2006; 60(5):432–435. [PubMed: 16581033]

Smith PH, Earp JA, DeVellis R. Measuring battering: Development of the Women's Experience with Battering (WEB) scale. Women's Health. 1995; 1(4):273–288. [PubMed: 9373384]

Straus, MA.; Hamby, SL.; Warren, WL. Conflict tactics scales handbook. Western Psychological Services; Los Angeles: 2003.

Sutherland CA, Sullivan CM, Bybee DI. Effects of intimate partner violence versus poverty on women's health. Violence Against Women. 2001; 7(10):1122–1143.

Thompson RS, Bonomi AE, Anderson M, Reid RJ, Dimer JA, Carrell D, Rivara FP. Intimate partner violence: Prevalence, types, and chronicity in adult women. American Journal of Preventive Medicine. 2006; 30(6):447–457. [PubMed: 16704937]

Turner RJ, Wheaton B, Lloyd DA. The epidemiology of social stress. American Sociological Review. 1995; 60(1):104–125.

Tyrka AR, Price LH, Kao HT, Porton B, Marsella SA, Carpenter LL. Childhood maltreatment and telomere shortening: Preliminary support for an effect of early stress on cellular aging. Biological Psychiatry. 2009; 67:531–534. [PubMed: 19828140]

Ulrich YC. Women's reasons for leaving abusive spouses. Health Care for Women International. 1991; 12(4):465–473. [PubMed: 1955412]

Valdes AM, Andrew T, Gardner JP, Kimura M, Oelsner E, Cherkas LF, Spector TD. Obesity, cigarette smoking, and telomere length in women. Lancet. 2005; 366(9486):662–664. [PubMed: 16112303]

Wijma K, Samelius L, Wingren G, Wijma B. The association between ill-health and abuse: A cross-sectional population based study. Scandinavian Journal of Psychology. 2007; 48(6):567–575. [PubMed: 18028079]

Woods AB, Page GG, O'Campo P, Pugh LC, Ford D, Campbell JC. The mediation effect of posttraumatic stress disorder symptoms on the relationship of intimate partner violence and IFN-

gamma levels. American Journal of Community Psychology. 2005; 36(1–2):159–175. [PubMed: 16134052]

Wuest J, Merritt-Gray M. Beyond survival: Reclaiming self after leaving an abusive male partner. Canadian Journal of Nursing Research = Revue Canadienne De Recherche En Sciences Infirmieres. 2001; 32(4):79–94.

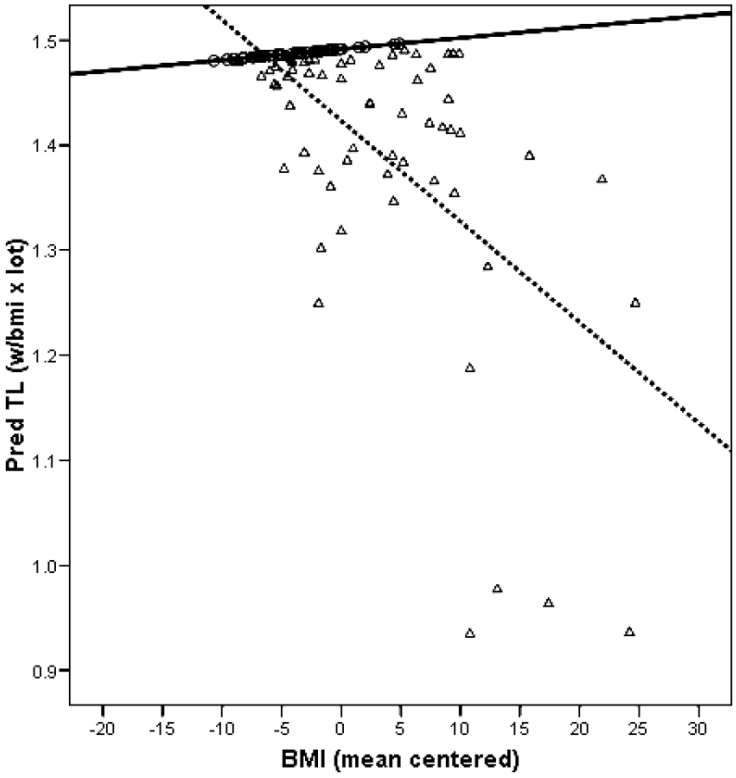

Figure 1.
Scatterplot of associations between mean-centered body mass index (BMI) and mean telomere length by group: formerly abused (Δ), never abused (0).

Table 1

Demographic Characteristics for the Total Sample and for the Two Study Groups of Never-Abused and Formerly Abused Women.

Demographic Characteristic	Total Sample (N = 112)	Study Groups		Statistics
		Never Abused (n = 46)	Formerly Abused (n = 66)	
Age (mean ± SD [range]) years	32.1 ± 9.3 (18–54)	27.8 ± 7.8 (18–52)	35.1 ± 9.3 (19–54)	t = 4.4, p < .001
				X^2 = 14.0, p < .01
Ethnicity (n [%])				Cramer's V =.36, p < .01
White	42 (37.5)	20 (43.5)	22 (33.3)	
Black	25 (22.3)	6 (13.0)	19 (28.8)	
Asian	17 (15.2)	12 (26.1)	5 (7.6)	
Latino	10 (8.9)	3 (6.5)	7 (10.6)	
Native American	1 (0.9)	0 (0.0)	1 (1.5)	
Multiracial	13 (11.6)	2 (4.3)	11 (16.7)	
Unknown	4 (3.6)	3 (6.5)	1 (1.5)	
Had children (n [%])	42 (37.5)	6 (14.6)	36 (59.0)	X^2 = 22.3, p < .001
Educational preparation (n [%])[a]				X^2 = 21.7, p = .001
Some high school	7 (6.3)		7 (10.6)	
High school grad or GED	16 (14.2)	2 (4.3)	14 (21.2)	
Some college	36 (32.1)	11 (23.9)	25 (37.9)	
College grad	30 (26.8)	17 (37.0)	13 (19.7)	
Postgraduate study	22 (19.6)	15 (32.6)	7 (10.6)	
Employed (n [%])	68 (60.7)	31 (67.4)	37 (56.1)	X^2 = 1.5, p = .23
Monthly income ($)				
mean	2151	2657	1800	
median (25%, 75%)[b]	1325 (600, 2700)	2000 (1000, 3909)	1000 (576, 2200)	Z = 2.4, p = .02[c]
Global rating of health (mean ± SD [range])	8.4 ± 1.2 (5–10)	8.9 ± 1.1 (6–10)	8.0 ± 1.2(5–10)	t = 4.0, p < .001
Body mass index (mean ± SD)	27.7 ± 7.3	23.8 ± 3.6	30.4 ± 8.0	
median range	25.8 (17–52.4)	24.0 (17–32.6)	28.6 (18.8–52.4)	t = 5.9, p < .001
100 cigarettes---lifetime (n [%])	38 (33.9)	6 (13)	32 (48.5)	t = 4.1, p < .001
Cigarette pack years (mean ± SD)	5.4 ± 5.3	2.1 ± 1.7	6.0 ± 5.5	t = 3.3, p < .01
Lifetime trauma exposures (mean ± SD [range])	9.6 ± 5.8 (0–23)	5.1 ± 3.7 (0–15)	12.7 ± 4.8 (4–23)	t = 9.1, p < .001

[a] N = 111.

[b] N = 110.

[c] Mann-Whitney U-test.

Table 2

Intimate Partner Violence (IPV) Exposure Among Formerly Abused Women (n = 66)

	Formerly Abused Women %
Type of Intimate Partner Violence	
Psychological aggression	100
Minor	100
Severe	91
Sexual coercion	64
Minor	64
Severe	50
Physical assault	91
Minor	89
Severe	79
Injury	85
Minor	80
Severe	58
Relationship to abuser (n [%])	
Husband	15 (22.7)
Boyfriend	46 (69.7)
Girlfriend	3 (4.5)
Acquaintance	2 (3.0)
Length of time in abusive relationship (years) mean	4.8
median (25%, 75%)	3.0 (1.0, 6.5)
Length of time since abuse (years)	
mean	4.7
median (25%, 75%)	2.0 (1.5, 6.0)

Note. Data on type of IPV were from participants' scores on the Revised Conflict Tactics Scale. Prevalence for type of violence is the percentage of women who reported at least one instance of that type of IPV during the last year of her relationship.

Table 3

Depression and Stress Scores and Telomere Length in Never-Abused and Formerly Abused Women (mean ± SD)

Variable	Total Sample (*N* = 112)	Study Groups		Statistics (unpaired *t*-test)
		Never Abused (*n* = 41)	Formerly Abused (*n* = 61)	
Beck Depression Inventory score[a]	13.2 ± 10.9	7.4 ± 7.9	17.3 ± 10.9	$t = 5.5$, $p < .001$
Perceived Stress Scale score	16.9 ± 7.7	13.0 ± 7.2	19.6 ± 6.8	$t = 4.9$, $p < .001$
Wheaton Social Stress Inventory score				
Total exposure	23.7 ± 9.7	17.3 ± 7.4	28.2 ± 8.8	$t = 6.9$, $p < .001$
Total severity	59.2 ± 31.0	37.6 ± 20.5	74.3 ± 28.2	$t = 8.0$, $p < .001$
Telomere length (t/s ratio [range])[b]	1.44 ± .26 (0.89–2.26)	1.51 ± .24 (1.13–2.15)	1.39 ± .26 (0.89–2.26)	$t = 2.4$, $p = .02$

[a] $N = 111$.

[b] $N = 102$.

Table 4

Bivariate Correlations Between Telomere Length and Salient Variables Equal to or Greater than 0.20 in Absolute Value ($N = 102$).

Variable	Telomere Length (units)	*p*
Subset 1		
Age	−.23	.02
BMI	−.23	.02
Subset 2		
Health rating	.27	.006
Had children	.37	< .001
Smoked 100 cigarettes ever	.20	.04
Subset 3		
Length of time abused	−.32	.001
Time since abuse	−.21	.03
Psychological aggression—minor	−.23	.02
Physical assault—minor	−.22	.02
Injury—minor	−.26	.009
Sexual coercion—Severe	−.25	.01
Total lifetime trauma exposures	−.21	.04

Note. BMI = body mass index.

Table 5

Multiple Regression Analysis Summary Table for Two Variables Predicting Telomere Length.

	Unstandardized Coefficients				95% Confidence Interval for *B*		
Model	***B***	**Standard Error**	***t***	***p***	**Lower Bound**	**Upper Bound**	**Part r^2**
(Constant)	1.23	.10	12.47	.000	1.031	1.421	
Have children	−.15	.05	−2.82	.006	−.257	−.045	.067
Length of time abused in years	−.01	.05	−2.11	.038	−.024	−.001	.037

Note. $R^2 = .17$ ($N = 102$, $p < .001$).