Marital Disruption is Associated with Shorter Salivary Telomere Length in a Probability Sample of Older Adults

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Abstract

Rationale—Marital disruption (i.e., marital separation, divorce) is associated with a wide range of poor mental and physical health outcomes, including increased risk for all-cause mortality. One biological intermediary that may help explain the association between marital disruption and poor health is accelerated cellular aging.

Objective—This study examines the association between marital disruption and salivary telomere length in a United States probability sample of adults 50 years of age.

Method—Participants were 3,526 individuals who participated in the 2008 wave of the Health and Retirement Study. Telomere length assays were performed using quantitative real-time polymerase chain reaction (qPCR) on DNA extracted from saliva samples. Health and lifestyle factors, traumatic and stressful life events, and neuroticism were assessed via self-report. Linear regression analyses were conducted to examine the associations between predictor variables and salivary telomere length.

Results—Based on their marital status data in the 2006 wave, people who were separated or divorced had shorter salivary telomeres than people who were continuously married or had never been married, and the association between marital disruption and salivary telomere length was not moderated by gender or neuroticism. Furthermore, the association between marital disruption and salivary telomere length remained statistically significant after adjusting for demographic and socioeconomic variables, neuroticism, cigarette use, body mass, traumatic life events, and other stressful life events. Additionally, results revealed that currently married adults with a history of divorce evidenced shorter salivary telomeres than people who were continuously married or never married.

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Conclusion—Accelerated cellular aging, as indexed by telomere shortening, may be one pathway through which marital disruption is associated with morbidity and mortality.

A robust literature links marital disruption (i.e., marital separation or divorce) to a range of poor health outcomes, including increased risk for all-cause mortality (Alviar et al., 2014; Dupre et al., 2015; Sbarra & Law, 2011; Shor et al., 2012). For example, in a long-term study of the Uppsala Birth Cohort, being divorced placed both men and women in the highest risk groups for early mortality, with a 46% and 27% higher relative mortality risk than their married counterparts, respectively (Donrovich et al., 2014). Similarly, in a sample of over 3.5 million adults, married participants had lower odds of any cardiovascular disease (OR = 0.95), whereas divorced participants had higher odds (OR = 1.05) relative to single adults (Alviar et al., 2014). Divorce is also associated with significantly elevated risk for hospital-diagnosed infectious diseases (Nielsen et al., 2014). In addition, having a history of divorce, even for those who have remarried, has been associated with negative health outcomes, including increased frequency of illness (Lorenz et al., 2006), risk of developing coronary heart disease (Smith et al., 2011), coronary mortality (Matthews & Gump, 2002), and all cause mortality (Tucker et al., 1996). A critical need for the research in this area is to identify biologically-plausible intermediaries that can explain this pattern of overall risk (Sbarra et al., 2012). The current study was conducted to evaluate the hypothesis that marital disruption might accelerate cellular aging, as operationalized by telomere shortening.

Telomeres are DNA-protein structures that are located at the ends of chromosomes that serve to maintain DNA integrity during cell division (Armanios & Blackburn, 2012). Telomeres naturally shorten with successive cell divisions, and gradual shortening of telomeres after each cell division eventually can lead to a loss of cellular division capacity and cell death (Lin et al., 2009). Consequently, telomere length has come to be viewed as a biomarker of cellular aging (Lin et al., 2009; Sanders & Newman, 2013), as well as a potential biomarker for factors that contribute to aging and age-related diseases (Lin et al., 2009). A meta-analysis of 124 cross-sectional and five longitudinal studies examining the association between age and telomere length yielded a weighted effect size (r) of $-.34$ and a yearly loss of 24.7 base pairs (Müezzinler et al., 2013). Meta-analytic results further indicate that shorter telomere length is significantly associated with a variety of health outcomes, including cancer (Wentzensen et al., 2011), and myocardial infarction, stroke, and type 2 diabetes mellitus (D'Mello et al., 2015), as well as with mortality (Deelen et al., 2014).

For many adults, the end of marriage can be a highly stressful event (Sbarra et al., 2015), and it is well known that psychosocial stress can alter a range of health-relevant biological processes (e.g., Miller et al., 2009; Segerstrom & Miller, 2004), including telomere length. Meta-analytic findings across eight studies (involving 1,143 people) demonstrate a moderate-sized negative association ($r = -.25$) between perceived stress and telomere length (Schutte & Malouff, 2014). A wide variety of life stressors are also associated with telomere length. For example, telomere shortening is associated with childhood maltreatment (Tyrka

et al., 2010) and general childhood adverse life events, such as parental unemployment or having a chronic or serious illness (Kananen et al., 2010). Adverse life events occurring in adulthood also are associated with telomere shortening. For example, women with histories of intimate partner violence have significantly shorter telomeres than women who have not experienced violence in an intimate relationship (Humphreys et al., 2012).

Although there are no studies to our knowledge that have examined the association between marital disruption and telomere length, a handful of studies have examined martial status and telomere length, and the results are mixed. For example, there was no association between marital status (married versus not married) and telomere length in a Finnish sample of men and women aged 30–64 years (Ahola et al., 2012) or a sample of Chinese women aged 40–70 years (Cui et al., 2013). In contrast, a study of Taiwanese men and women aged 65–74 years found that unmarried adults had shorter telomeres than married adults, although this difference was no longer statistically significant when adjusting for demographics and other potential covariates (Yen & Lung, 2013). Finally, a study of Americans aged 40–64 years found that unmarried participants had significantly shorter telomeres than participants who were married or living with a partner, and this difference remained statistically significant after adjusting for demographics and other potential covariates (Mainous et al., 2011). Although this research provides a basis for understanding marital status differences in telomere length, no studies focus explicitly on marital disruption, and a direct comparison between separated/divorced and married adults is needed to better understand whether the end of marriage is associated with accelerated cellular aging.

The current study was conducted to evaluate the association between marital disruption and salivary telomere length in a probability sample of older adults. We hypothesized that people who were separated or divorced would have shorter salivary telomeres than those who were continuously married or never married; we did not expect differences in salivary telomere length between people who were separated or divorced and people who were widowed, as death of a spouse is viewed as a highly stressful event (Holmes & Rahe, 1967; Stroebe et al., 2007), and recent studies demonstrate considerable overlap in grief-related responses to divorce and bereavement (e.g., Papa et al., 2014). However, we did expect differences in salivary telomere length between divorced and single adults, as contemporary research on *singlehood* indicates that is inaccurate to equate being single with social isolation (DePaulo, 2015), whereas considerable evidence suggests that marital separation, on average, is a highly stressful process (Sbarra et al., 2015). Therefore, we expected that separated or divorced participants would evidence shorter salivary telomeres relative to (a) continuously married individuals, and (b) never married individuals. Finally, growing evidence indicates that the main effect of divorce on health outcomes is qualified by interactions with both gender (Sbarra & Law, 2011) and psychological variables that reflect *negative affectivity* (Sbarra et al., 2015), which is the trait-like tendency to experience a high degree of negative emotion and to have a high level of dissatisfaction with one's self and prospects for the future (Watson & Clark, 1984). Given these prior findings, we also hypothesized that the association between marital disruption and salivary telomere length would be potentiated for men and for people reporting high levels of neuroticism, a dimension of personality that taps negative affectivity.

A second aim of the study was to evaluate whether the hypothesized associations between marital disruption and salivary telomere length would remain statistically significant when adjusting for potential confounds. Telomere length is negatively correlated with age (Müezzinler et al., 2013) and positively correlated with educational attainment (Steptoe et al., 2011) and, on average, longer telomeres are found in females relative to males (Gardner et al., 2014), and in African Americans relative to Whites (Hunt et al., 2008; Needham et al., 2013). Furthermore, telomere length is associated with personality factors such as neuroticism (van Ockenburg et al., 2014), and health behaviors and lifestyle factors such as cigarette smoking (Valdes et al., 2005) and body mass index (BMI) (Müezzinler et al., 2014). Because many of the variables that covary with telomere length are also associated with the probability of marital disruption (Kendler et al., 2002; Kurdek, 1993; Roberts et al., 2007; Tucker et al., 1998), we were interested in evaluating the incremental association between marital disruption and salivary telomere length, holding constant demographic and socioeconomic variables, neuroticism, cigarette smoking, BMI, and stressors that were unlikely to result from marital disruption but that could potentially contribute to the increased probability of both marital disruption and telomere shortening (i.e., childhood traumatic life events, traumatic life events, other stressful life events).

Method

Sample

Participants were drawn from the Health and Retirement Study (HRS), which is an ongoing, multistate probability cohort sample of households in the United States including at least one person over the age of 50. In 2008, a random half of HRS households were preselected to additionally participate in an Enhanced Face-to-Face Interview, which included a Leave-Behind Questionnaire on psychosocial topics and collection of saliva. We used marital status data from 2006 and included people who reported in 2006 that they were (a) separated or divorced, (b) continuously married, (c) married with a history of divorce, (d) widowed, or (e) never married. Data were collected from more than one member of the household in nearly half of the households. To account for nonindepenence of household data, we selected for analyses all people in which data were available for only one household member and, for each multi-participant household, we selected at random one member, for a final sample of 3,526 people. The sample included 556 separated or divorced, 1,450 continuously married, 486 married with a history of divorce, 895 widowed, and 139 never married individuals; the weighted percentage for each marital status group was 18.8%, 39.5%, 15.3%, 21.2%, and 5.2%, respectively. After weighting, the mean age of the sample was 65.08 ($SD = 10.00$) and participants reported a mean of 12.90 ($SD = 3.03$) years of education. Approximately half (56.7%) of the weighted sample was female, and the racial composition of the weighted sample was 87.9% White, 9.6% Black, and 2.6% other; 7.4% of the weighted sample was Latino.

Outcome Variable

Telomere Length (Institute for Social Research, 2013)—Telomere length was measured from saliva. Salivary telomere length correlates highly with telomere length as measured by blood leukocyte (Mitchell et al., 2014; Theall et al., 2013) and strong positive

correlations are observed for telomere length measured in leukocytes, skeletal muscle, skin, and subcutaneous fat (Daniali et al., 2013). In addition, salivary telomere length correlates with other risk factors for adverse health outcomes (e.g., familial risk for depression; Gotlib et al., 2015) and known correlates of telomere length as measured by blood leukocytes, including age (Chen et al., 2015), tobacco smoking (Chen et al., 2015), perceived stress (Chen et al., 2015), other measures of adversity and disadvantage (Mitchell et al., 2014; Theall et al., 2013), and hypothalamic-pituitary axis (HPA) dysregulation (i.e., coritsol reactivity to stress; Gotlib et al., 2015). Saliva samples were obtained using an Oragene® Collection Kit, and samples were sent to a central laboratory for DNA extraction. All DNA samples were sent in 96 well plates to Telome Health, where they were stored in their original plates in an −80° freezer upon arrival and assayed within 1 week. Telomere length assays were performed using quantitative real-time polymerase chain reaction (qPCR), adapted from a method by Cawthon (2002) and described in greater detail elsewhere (Institute for Social Research, 2013). The ratio of telomere sequence copy number in each respondent's sample (T) to a single gene copy number (S) was determined. This T/S ratio is proportional to mean telomere length. Genomic DNA from pooled 100 male donors was used as the standard reference. A triplicate serial dilution was made to create a 6-point standard curve containing 5, 1.6667, 0.5556, 0.1852, 0.6173 and 0.02058 ng of DNA respectively in each reaction tube. The quality control success rate was 98.17%. Mean telomere and single-gene assay coefficients of variation were 0.884 ($SD = 0.32$) and 0.937 ($SD = 0.33$), respectively. The coefficients of variation for mean T/S ratios of quality control samples ranged from 3.5% to 6.3%, indicating low measurement error. Because salivary telomere length was not normally distributed in this sample, data were transformed using the natural logarithm to improve normality, which is a common practice in this area of research (e.g., Chen et al., 2015).

Independent Variable

Four dummy-variable codes were used to code for the five marital status categories: separated or divorced, continuously married, married with a history of divorce, widowed, and never married. The separated or divorced group served as the reference (i.e., comparison) group and this group was assigned a value of 0 for every dummy-coded variable. The other marital status groups were given a value of 1 on the dummy-coded variable that contrasted it with the reference group in the analyses and a value of 0 on the other dummy-coded variables.

Moderators and Covariates

Neuroticism—Personality was measured in 2008 with an adjective measure developed for the Midlife Development in the United States survey by selecting adjectives that (a) were most consistently identified in the literature as trait markers for Big Five personality traits in existing personality trait lists, and (b) demonstrated the highest factor loadings or item-total correlations during scale construction in 1994 in a United States probability sample of 1,000 people between the ages of 30 and 70 conducted (Zimprich et al., 2012). The neuroticism scale consists of four adjectives (*moody, nervous, calm, worrying*) that were rated on a 4-point scale indicating how well each adjective described the respondent (1 = *not at all*, 4 = *a lot*). Items were reverse scored as necessary and averaged to create a total score, with higher

scores indicating higher neuroticism (α = 74). This scale significantly correlates with the NEO neuroticism scale (see http://www.brandeis.edu/departments/psych/lachman/instruments/other-instruments.html).

Body Mass Index—In 2008, participants were asked their height and weight and body mass index (BMI) was based on their self-report using the formula, BMI = [weight in pounds/(height in inches)^2] × 703. HRS interviewers measured height and weight for a subset of 3,283 people in the current sample and BMI derived from self-report was highly correlated (r = .90) with BMI derived from measured height and weight.

Childhood Traumatic Life Events—Traumatic events occurring during childhood were measured in 2008 with a checklist, in which participants were asked to indicate whether each of four events (e.g., *parents drink or use drugs so often that it caused problems in the family; physically abused by either of your parents*) had occurred before they were 18 years old. Items were taken from an ongoing longitudinal study on the health consequences of trauma in older adults (Krause et al., 2004) and events such as these are common to many measures of traumatic life events. A measure of exposure to traumatic life events before the age of 18 was calculated by summing the number of events checked as having occurred, with scores > 2 recoded as 2, due to the small number of people who experienced more than 2 childhood traumas.

Traumatic Life Events—Traumatic life events were measured in 2008 with a checklist, in which participants were asked to indicate whether each of seven events (e.g., *ever been in a major fire, flood, earthquake or other natural disaster; ever have a life-threatening illness or accident*) had occurred at any point in their life. Items were taken from an ongoing longitudinal study on the health consequences of trauma in older adults (Krause et al., 2004) and events such as these are common to many measures of traumatic life events. A measure of lifetime exposure to traumatic life events was calculated by summing the number of events checked as having occurred, with scores > 4 recoded as 4, due to the small number of people who experienced more than 4 traumas.

Stressful Life Events—Stressful life events were measured in 2008 with a checklist in which participants were asked to indicate whether each of six stressful life events had occurred in the last five years (e.g., *involuntarily lost a job for reasons other than retirement; robbed or had your home burglarized*). Events such as these are common to self-report measures of life stress (Turner et al., 1995) and assess for the occurrence of events that are unlikely to be caused by a marital disruption. A measure of recent stressful life events was calculated by summing the number of stressful events checked as having occurred, with scores > 3 recoded as 3, due to the small number of people who experienced more than 3 events.

Demographic Variables—Standard demographic questions were administered to assess for marital status history, age, gender, race (coded as White, Black, other), and ethnicity (Latino/Hispanic, not Latino/Hispanic); we used demographic data from the 2006 wave.

Socioeconomic Variables—Education was operationalized based on a continuous measure of years of educational attainment. Income was measured as the total household income, based on a sum of unemployment and workers compensation, Supplemental Security Income (SSI) and social security disability, pensions and annuities, social security retirement, other government transfers, household capital income, and other income. Because total household income was not normally distributed, data were transformed using the natural logarithm to improve normality. Subjective social status was assessed with the MacArthur Scale of Subjective Social Status (Adler et al., 2000), in which participants are shown a picture of a 10-rung ladder and instructed to "Think of this ladder as representing where people stand in our society, including having more money, more education and better jobs," and then rate where they would place themselves, with higher rungs representing higher social standing; we used participants' rating as a continuous measure. Data from the 2006 wave were used for all socioeconomic variables.

Statistical Analysis

The association between marital disruption and salivary telomere length was examined using linear regression. In Model 1, we regressed 2008 salivary telomere length on 2006 marital status (separated or divorced, continuously married, married with a history of divorce, widowed, and never married, with the separated or divorced group as the reference group), statistically accounting for demographic variables assessed in 2006. Because statistical interactions qualify the interpretation of a main effect, we followed Aiken and West's (1991) recommended top-down approach for testing moderation and first evaluated whether the association between marital status and salivary telomere length was moderated by gender or neuroticism. Multiplicative interaction terms were created and entered in separate models to test whether the interaction terms were significantly associated with telomere length, controlling for the component terms; neuroticism was mean deviated (i.e., centered) prior to creating the interaction term (Whisman & McClelland, 2005). Specifically, to test for gender moderation, we created four Gender × Marital Status interaction terms, one for each the marital status group other than the separated or divorced group (i.e., the reference group), and entered these as a set into the multiple regression equation predicting salivary telomere length, along with the component terms; to test for the potential moderating role of neuroticism, we created four Neuroticism × Marital Status terms. Individual Gender × Marital Status or Neuroticism × Marital Status terms were examined if the association between the set of interaction terms and salivary telomere length was statistically significant (Cohen et al., 2003). If the main or moderated association between marital disruption and salivary telomere length was statistically significant, we then evaluated whether the association remained statistically significant, additionally accounting for potential confounds of demographic and socioeconomic variables assessed in 2006 (Model 1) and then additionally accounting for the potential confounds of neuroticism, cigarette smoking, BMI, childhood traumatic life events, traumatic life events, and stressful life events, each of which were assessed in 2008 (Model 2). Because at least one study found a nonlinear association between age and telomere length (Rehkopf et al., 2013), we included an age-squared term in these analyses to account for potential nonlinearity in the association between age and salivary telomere length. We used HRS sample weights (i.e., the 2008 Psychosocial Leave-Behind sample weights) for descriptive statistics and all analyses. The sample weights

account for differential selection probabilities, adjust for differential baseline and wave-specific non-response, and make the weighted sample representative of non-institutionalized individuals in the United States population in the age-eligible range.

Results

After weighting, mean salivary telomere length was 1.37 ($SD = 0.57$); the mean log transformed salivary telomere length was 0.12 ($SD = 0.12$). Descriptive statistics for other study variables are presented separately by marital status groups in Table 1.

We first evaluated whether the association between marital status and salivary telomere length was moderated by gender or neuroticism. After controlling for the component terms, salivary telomere length was not significantly associated with the set of Gender × Marital Status interaction terms, $F(4,3577) = 0.34$, $p = .853$, or the set of Neuroticism × Marital Status interaction terms, $F(4,3458) = 1.48$, $p = .207$. None of the four separate Gender × Marital Status interaction terms were significantly associated with salivary telomere length (all p values > .30). Although the four Neuroticism × Marital Status interaction terms were not significantly associated with salivary telomere length as a set, the Neuroticism × Continuously Married interaction term was statistically significant, $b = .018$, 95% CI = .000, .035, $\beta = .058$, $p = .039$. As predicted, the difference in salivary telomere length between the separated or divorced group and the continuously married group increased in magnitude with increasing levels of neuroticism. However, the magnitude of the interaction was small and when we included demographic and socioeconomic covariates into the regression analysis (Table 2, Model 1), the interaction was no longer statistically significant. Taken together, these results suggest that differences in salivary telomere length between the separated or divorced groups and each of the other marital status groups did not consistently differ as a function of gender or neuroticism. Therefore, no further tests of moderation were conducted.

Next, we evaluated the multivariate association between marital disruption and salivary telomere length after statistically adjusting for demographic and socioeconomic variables. As can be seen in Table 2 (Model 1), holding demographic and socioeconomic variables constant, people who were separated or divorced had shorter salivary telomeres relative to (a) continuously married individuals, and (b) never married individuals. After statistically adjusting for demographic and socioeconomic variables, the mean salivary telomere length was 0.104 ($SD = 0.126$) for the separated or divorced group, 0.123 ($SD = 0.118$) for the continuously married group, 0.105 ($SD = 0.119$) for the married with a history of divorce group, 0.111 ($SD = 0.118$) for the widowed group, and 0.128 ($SD = 0.104$) for the never married group. With respect to the marital status groups that differed significantly from the marital disruption group, the effect size (i.e., d) for the difference in salivary telomere length between people who were separated or divorced was −.16 for people who were continuously married and −.20 for people who had never been married, which translate into correlations (r) of −.08 and −.10, respectively.

In Model 2, we added the potential confounds of neuroticism, cigarette smoking, BMI, childhood traumatic life events, traumatic life events, and stressful life events to the

regression equation predicting salivary telomere length. As can be seen in Table 2, results indicated that after additionally adjusting for personality, health behaviors, lifestyle factors, and traumatic and stressful life events, the association between marital disruption and salivary telomere length remained statistically significant.

Finally, to evaluate whether a history of marital disruption was associated with accelerated cellular aging, we ran the multiple regression analysis a second time, with people who were married with a history of divorce as the reference group, statistically accounting for demographic and socioeconomic variables. Holding these variables constant, married individuals with a history of divorce had significantly shorter telomeres than continuously married individuals, $b = .019$, 95% CI = .007, .031, $\beta = .076$, $p = .003$, and never married individuals, $b = .022$, 95% CI = $-.000$, .045, $\beta = .041$, $p = .039$, but did not significantly differ from currently separated or divorced individuals, $b = -.003$, 95% CI = $-.017$, .011, $\beta = -.008$, $p = .733$, or widowed individuals, $b = .002$, 95% CI = $-.014$, .018, $\beta = .006$, $p = .814$. The effect size (i.e., d) for the difference in salivary telomere length between people with a history of divorce was $-.15$ for people who were continuously married and $-.20$ for people who had never been married, which translate into correlations (r) of $-.07$ and $-.10$, respectively.

Discussion

The present study was conducted to (a) examine the association between marital disruption (i.e., separation or divorce) and salivary telomere length in a population-based sample of adults 50 years of age, (b) test whether this association was moderated by participants' gender or neuroticism, and (c) evaluate whether this association remained statistically significant when adjusting for several possible confounds. Consistent with the first study hypothesis, marital disruption was significantly and negatively associated with salivary telomere length: people who were separated or divorced had shorter salivary telomeres than people who were continuously married or never married. Furthermore, we found little evidence to support the moderation hypotheses, as neither gender nor neuroticism consistently potentiated the association between marital disruption and salivary telomere length. Finally, the association between marital disruption and salivary telomere length remained statistically significant (and essentially unchanged) when adjusting for the potential confounding influence of demographic characteristics, socioeconomic variables, neuroticism, health and lifestyle factors (cigarette smoking, BMI), childhood and lifetime traumatic events, and other stressful events (that were unlikely to result from marital disruption but that could potentially contribute to the increased probability of both marital disruption and telomere shortening).

Before discussing these findings in greater detail, it is worth noting a few methodological issues specific to the HRS. First, although it seems unlikely that shorter salivary telomere length is a preexisting or acquired marker for people who subsequently become separated or divorced, the study was cross-sectional in design and so it cannot be concluded that marital disruption caused telomere shortening. Therefore, longitudinal research examining the prospective association between marital disruption and telomere shortening would be an important topic for future research. Second, in testing for moderation effects, the group sizes

for some of the cells were likely to be small, resulting in low statistical power for detecting statistical interactions. In addition, we examined only two potential moderators, and future research could examine other variables that have been suggested as potential moderators of the association between marital disruption and adjustment in adults (e.g., Amato, 2000). Third, although we found that the association between marital disruption and salivary telomere length remained statistically significant when adjusting for a variety of potential confounds, it is possible that some other unmeasured third variable increased the likelihood of both marital disruption and telomere shortening. Statistically adjusting for other variables that are associated with both marital disruption and telomere shortening in future research would increase confidence that the association between marital disruption and telomere shortening is not secondary to some other unmeasured third factor. Finally, participants were all 50 years of age. Although the divorce rate for adults 50 years and over doubled between 1990 and 2010 (Brown & Lin, 2012), which highlights the importance of studying older adults when examining the health-relevant correlates of marital disruption, future research is needed to examine whether marital disruption is associated with shorter telomeres in younger individuals.

This is the first study that has evaluated the association between marital disruption and telomere length. Although prior studies have examined the association between *marital status* and telomere length, these studies have compared married versus unmarried individuals without a specific focus on marital disruption. Therefore, the current findings extend prior research by adding specificity and demonstrating that compared to continuously married and never married adults, separated or divorced adults have shorted salivary telomeres, which may be due to the stress that is generally experienced by people going through a separation or divorce. The effect sizes (i.e., *d*) observed for the comparisons between the separated or divorced group and the other groups were −.16 for people who were continuously married and −.20 for people who had never been married; these *d* values translate into correlations of −.08 and −.10, respectively. These effect sizes are roughly comparable in magnitude to the effect sizes obtained in prior meta-analyses of the association between telomere length and gender (*d* = .09, with women having longer telomeres than men; Gardner et al., 2014) and BMI (*r* = −.06; Müezzinler et al., 2014), although they are smaller than the effect obtained in a prior meta-analysis of the association between telomere length and perceived stress (*r* = −.25; Schutte & Malouff, 2014). Therefore, the association we found between marital disruption and telomere length is roughly comparable to the magnitude found for some other correlates of accelerated cellular aging. It will be incumbent upon future research to determine if small differences in telomere length translate into meaningful pathophysiological differences or clinical health outcomes.

Although it is widely documented that marital disruption is associated with a range of morbidities and risk for early death, the biological intermediaries that explain this association are not well documented (Sbarra et al., 2012). Results of the present study suggest that accelerated cellular aging may be one mechanistic pathway linking the end of marriage to distal health outcomes. If future longitudinal research confirms that the experience of marital disruption is associated with subsequent changes in telomere length, an obvious question is what psychosocial processes lead to shorter telomeres among

separated or divorced adults. The end of marriage can be highly stressful for many people (Lorenz et al., 1996), and it is well known that perceived stress is associated with immunological inflammatory responses that can promote telomere shortening (O'Donovan et al., 2011; Segerstrom & Miller, 2004). Whereas the strength of the current investigation rests in its large and representative sample, future research in this area will benefit from more precise measurements of the psychological stress that follows from marital disruption and whether the experience of psychological stress associated with the ending of marriage can explain marital status group differences in salivary telomere length.

Results from the current study also suggest that people who are married but have a history of divorce had shorter telomeres than people who were continuously married or never married. Furthermore, the mean salivary telomere length for people with a history of divorce did not significantly differ from the mean salivary telomere length for people who were currently separated or divorced. These results suggest that the effects of marital disruption on accelerated cellular ageing may be found over extended periods, during which other life experiences occur. In particular, given that we looked at lifetime history of divorce in people who were currently married, the results suggest, to the extent that they are causal, that remarriage does not ameliorate the potential effects of marital disruption on telomere length. The larger literature on divorce, remarriage, and health is inconsistent, with some studies showing favorable effects (i.e., remarriage reducing health risks) and others showing no such differences (Mason & Sbarra, 2012; Sbarra et al., 2014). Given that there is some preliminary research from some small-scale studies suggesting that cellular aging can be slowed or reversed over short periods (for a review, see Epel, 2012), the current findings are of considerable interest, and the results from this work suggest that remarriage does not appear to reverse the cellular aging associated with a lifetime history of marital disruption.

In summary, results from the current study suggest that (a) marital disruption was associated with shorter salivary telomeres; (b) this association was not moderated by gender or neuroticism (i.e., the association between marital disruption and salivary telomere length did not vary as a function of either of these variables that have been shown in prior research to qualify the effects of divorce on health outcomes); and (c) this association remained statistically significant when adjusting for several important potential confounds. These findings support continued research on marital disruption and telomere biology, as shortened telomeres may be one pathway by which marital disruption contributes to adverse health outcomes, including mortality. Future research involving multiple waves of data collection is needed to test whether marital disruption is associated with subsequent changes in telomere length, which in turn increases the likelihood of subsequent adverse health outcomes, and to evaluate the pathways by which marital disruption may contribute to telomere shortening.

Acknowledgments

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Research Highlights

- Marital disruption is associated with poor health and all-cause mortality

- Marital disruption may accelerate cellular aging as measured by telomere shortening

- Marital disruption was associated with shorter telomeres in a probability sample

- This association was not moderated by gender or neuroticism

- This association was incremental to other known correlates of shorter telomeres

Table 1

Descriptive Information for Study Variables by Marital Status Groups

Variable	Separated or Divorced		Married Continuously		Married with a History of Divorce		Widowed		Never Married	
	M (SD)	%	M (SD)	%	M (SD)	%	M (SD)	%	M (SD)	%
Age	61.7 (8.1)		64.3 (9.2)		60.8 (7.0)		73.6 (10.1)		61.5 (8.4)	
Women		63.8		47.5		43.7		79.1		48.1
White		78.8		92.3		90.5		87.5		79.7
Black		18.5		5.0		6.2		10.3		18.7
Other		2.7		2.7		3.1		2.1		1.6
Latino		9.8		7.6		7.5		5.9		3.7
Education	12.6 (3.1)		13.3 (2.9)		13.3 (2.7)		11.9 (3.1)		14.0 (2.8)	
Total household income (log10)	4.3 (0.7)		4.8 (0.5)		4.8 (0.5)		4.3 (0.5)		4.2 (1.1)	
Subjective social status	5.8 (1.9)		6.6 (1.7)		6.6 (1.6)		6.3 (1.8)		6.2 (1.9)	
Neuroticism	2.1 (0.7)		2.0 (0.6)		2.0 (0.6)		2.0 (0.6)		2.1 (0.7)	
Cigarette smoker		67.6		51.9		66.7		53.4		52.4
Body mass index	28.9 (6.6)		28.4 (5.7)		28.7 (5.5)		27.7 (6.5)		28.3 (6.5)	
Childhood traumatic life events	0.6 (0.7)		0.4 (0.6)		0.6 (0.7)		0.4 (0.6)		0.4 (0.7)	
Traumatic life events	1.4 (1.2)		1.1 (1.1)		1.2 (1.2)		1.5 (1.2)		0.7 (0.8)	
Stressful life events	0.5 (0.8)		0.3 (0.6)		0.4 (0.7)		0.2 (0.6)		0.4 (0.7)	

Table 2

Results from Linear Regression Analyses Predicting Salivary Telomere Length

Variable	Model 1				Model 2			
	b	95% CI	β	p	b	95% CI	β	p
Marital status[1]								
Married continuously	.021	.010, 0.033	.086	.001	.025	.013, .037	.103	.000
Married with a history of divorce	.003	−.011, .017	.008	.733	.005	−.011, .021	.016	.494
Widowed	.004	−.010, .018	.015	.546	.009	−.007, .025	.031	.230
Never married	.025	.010, .045	.046	.016	.023	.001, .045	.041	.036
Age	−.007	−.013, −.001	−.581	.013	−.006	−.012, −.000	−.486	.046
Age-squared	.000	.000, .000	.461	.048	.000	.000, .000	.399	.102
Gender (Women)	.010	.002, .018	.042	.020	.008	−.002, .018	.034	.072
Race[2]								
Black	.043	.027, .069	.101	.000	.041	.025, .057	.097	.000
Other	.023	−.004, .050	.028	.110	.014	−.015, .043	.017	.338
Ethnicity (Latino)	.008	−.010, .030	.018	.346	.005	−.013, .023	.012	.553
Education	.001	−.001, .003	.024	.239	.002	.000, .004	.044	.042
Total household income	−.015	−.023, −.007	−.072	.000	−.015	−.023, −.007	−.071	.001
Subjective social status	.003	.001, .005	.051	.007	.003	.001, .005	.047	.019
Neuroticism					.003	−.005, .011	.016	.405
Cigarette smoker					−.008	−.016, −.000	−.031	.088
Body mass index					.001	.000, .000	.048	.009
Childhood traumatic life events					.006	.000, .012	.031	.097
Traumatic life events					−.003	−.007, .001	−.029	.118
Stressful life events					.005	−.001, .011	.026	.178

Note. Model 1 includes demographic and socioeconomic covariates and Model 2 additionally includes the other covariates. *b* = unstandardized regression coefficient. CI = confidence interval. β = standardized regression coefficient.

[1] Separated or divorced is the reference group.

[2] White is the reference group.