Brief Report: Men in Emotionally Supportive Romantic Relationships

Experience Lower Levels of Oxidative Stress

Running head: Romantic relationships and oxidative stress

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Abstract. Objective: People who report being in high quality romantic relationships have better physical and psychological well-being, and live longer than people lacking such relationships. The present study investigated one possible physiological mechanism through which these physical health and longevity benefits may accrue, oxidative stress. Methods: 40 college males involved in romantic relationships provided self-reports on the quality of the relationship, and were assessed for two urinary biomarkers of oxidative stress, 8-OHdG and MDA. Results: Men who reported being in more emotionally nurturant relationships experienced lower levels of oxidative stress than men in lesser quality relationships. Conclusions: Oxidative stress may be a physiological mechanism by which positive romantic experiences manifest in health benefits, possibly leading to lower rates of senescence and disease.

People in supportive romantic relationships experience significant health benefits. Marriage is associated with lowered morbidity and mortality across a variety of acute and chronic health conditions, including cancer, heart attacks, and surgery (e.g., Gordon & Rosenthal, 1995). Though marriage itself was once thought to confer these benefits (especially for men; Ross et al., 1990), more recent studies indicate that relationship qualities play prominent roles in multiple points in disease trajectory, including etiology (Hibbard & Pope, 1993), symptom exacerbation (Vitaliano et al., 1993), and recovery (Helgeson, 1991). Perceived partner responsiveness—the belief that partners are cognizant of, sensitive to, and supportive of one's needs—may yield health benefits (Reis et al., 2004), while hostile conflict may have detrimental effects (Robles & Kiecolt-Glaser, 2003).

Though many outcomes of positive romantic interactions have been identified, the precise physiological processes through which they affect health remain poorly understood. Roles for cortisol and other hormones have been postulated. Blood pressure, cortisol, norepinephrine, and prolactin
elevate in response to relationship conflicts, particularly in women (Kiecolt-Glaser et al., 1996), while positive romantic interactions involving warm partner contact may increase circulating serum proteins, in turn promoting health and feelings of well-being (Matsunaga, 2009). Nonetheless, it is not clear how certain benefits—e.g., reduced risk of cancer—arise from reduction of psychosocial stressors. Multiple processes may be involved and some important mediators of the effects of relationship quality on health likely remain unidentified. One plausible candidate is oxidative stress.

Oxidative stress is a physiological state resulting from normal metabolic processes by which aerobic cells produce energy. During cell respiration, organic substances are oxidized and natural byproducts referred to as reactive oxygen species (ROS) are created. ROS are unstable. They react with other molecules and thereby damage cellular membranes, proteins, and DNA; e.g., most mutations result from oxidative damage (Denver et al., 2009). Antioxidant enzymes (e.g., superoxide dismutase, catalase) and, to a much lesser extent, dietary anti-oxidants defend against free radical injury by converting ROS into stable, harmless molecules. Oxidative stress is a state of physiological imbalance, characterized by a level of ROS production that exceeds antioxidative capacity.

Progressive and irreversible accrual of molecular oxidative damage likely generates senescence-related loss of function (see Muller et al., 2007). A vast literature addresses the role of oxidative stress in overt disease processes. (Web of Science generates ~34,000 peer-reviewed articles with keywords “oxidative stress” and “disease,” over half published in the last 5 years.) Oxidative damage plays a role in a wide array of chronic diseases, including cancer, neurodegenerative disease, (e.g., Alzheimer’s, Parkinson’s) and metabolic, vascular, and renal disease (e.g., Roberts & Sindhu, 2009; Schapira, 2008; Lambeth, 2007, and references within).

Little research has examined oxidative stress in healthy human populations. An organism’s net oxidative stress level may be readily, if indirectly, estimated via non-invasive biomarkers that
appear in urine. Human urinary biomarkers of oxidative stress widely vary and are fairly reliable across individuals over time (Mizoue et al., 2007). Factors known to affect these biomarkers in normal adults—e.g., exposure to contaminants, toxins, or smoking (e.g., Kimura et al., 2006), dietary factors (Mayne, 2003), lean body mass (Mizoue et al., 2007)—leave most variation unexplained.

Theory gives reason to suspect that relationship quality may covary with oxidative stress, especially in men. Evolutionary biologists have speculated that males exerting mating effort may pay costs for these efforts, partly in the form of increased production of ROS (e.g., due to increased metabolic rates) or lower levels of antioxidant enzymes (e.g., due to resources reallocated to mating effort; Alonso-Alvarez et al., 2007; Dowling & Simmons, 2009). By contrast, males (and perhaps females) in high quality relationships may exert less mating effort, thereby pay lower costs in the currency of oxidative damage and, as a result, enjoy enhanced longevity.

In a sample of healthy college men, we assessed the association between oxidative stress level and self-reported relationship quality, focusing on a measure related to Reis et al.’s (2004) notion of perceived partner responsiveness. We also measured testosterone and cortisol. Testosterone levels decrease when men are in stable, exclusive romantic relationships (see Gray & Campbell, 2009), presumably because testosterone promotes behavioral and morphological aspects of mating effort in most vertebrate males, including humans (e.g., Wingfield et al., 1990). Maintaining elevated testosterone may accordingly entail a cost of increased oxidative stress (Alonso Alvarez et al., 2007), and thereby mediate an effect of relationship quality on oxidative stress.

Cortisol is a major metabolic hormone, rendering glucose available for energy utilization, and is a major component of the stress response, which could be triggered by negative romantic interactions.

**METHODS**

*Participants*
Participants were 98 men who partly satisfied, by their participation, a research requirement of an introductory psychology class, 40 who reported being presently involved in a romantic relationship. They arrived for a scheduled lab session in groups of 1-4. After providing informed consent, each was given a questionnaire to complete in a private room. During the session, participants were asked to provide a 10 ml urine sample (immediately frozen at -20°C) and were given a sterile receptacle in which to collect a first-of-the-day urine sample 7 days after the initial session (returned immediately or frozen until it could be). Participants were also asked to provide a 10 ml saliva sample, and another saliva sample 7 days after the initial session, from which testosterone and cortisol were assayed; all samples were frozen at -20°C until assayed.

Assessment of Relationship Quality

Included in the questionnaires was a 35-item form of Ellis’s (1998) Partner-Specific Investment Inventory, a multicomponent measure of investment of time and resources into a relationship. High scorers report high levels of emotional nurturance, willingness to spend time with one’s partner, and future orientation in the relationship, and low levels of neglect and sexualizing of others. *A priori*, we selected one subscale to focus on, as it appears to relate to key components of Reis et al.’s notion of perceived partner responsiveness, conjectured to be key to the health benefits of “good” relationships: Expressive/Nurturing (EN). This subscale had 6 items (e.g., “I share my feelings with my partner,” “I comfort my partner when she is distressed,” “I trust my partner with secrets that I do not want anyone else to know”). We examined associations with the full inventory as well. Participants separately reported on their own and their partner’s investment in their relationships. Cronbach’s $\alpha$ for EN was .83 (self) and .87 (partner); self and partner versions correlated .74, $p < .001$. We used as our primary predictor of "relationship quality" a summed score of self- and partner- nurturance, encompassing both the feeling that one can safely share feelings
and inner thoughts with a partner, and the feeling of being nurtured by them in return. We also inquired about relationship length (mean = 28 months, sd = 33.7, median = 18).

**Urinary Biomarkers of Oxidative Stress**

Two widely used biomarkers of oxidative stress were assayed in urine. The most widely used urinary biomarker of oxidative DNA damage, 8-hydroxydeoxyguanosine (8-OHdG), is secreted into urine upon cellular repair of damaged DNA (e.g., Kimura et al., 2006). Malondialdehyde (MDA) is a biomarker of lipid peroxidation, reflecting oxidative damage to cell membranes and other tissues, and appears in urine as an endproduct of the oxidative degradation of lipids (e.g., Mayne, 2003).

8-OHdG was assayed using ELISA kits manufactured by the Japan Institute for the Control of Aging. MDA was assayed using ELISA kits distributed by Northwest Life Sciences Specialties. Both were performed in duplicate and standardized against levels of creatinine, quantified colorimetrically in quadruplicate (Taussky, 1954) in UNM’s Hominoid Reproductive Ecology Laboratory. Biomarker levels did not covary (linearly or curvilinearly) with time since waking.

In theory, an aggregate measure incorporating both biomarkers should assess levels of oxidative stress more validly than one. We hence created an aggregate measure of oxidative stress by \( z \)-scoring each biomarker at each time point and averaging, for each individual, available \( z \)-scores. Some subjects did not return a second urine sample, and four urine samples were too dilute (creatinine \( \leq \) 0.1 mg/ml) to produce reliable results. We report associations within the sample of all 40 men; results for the 29 men who returned two samples were stronger, but not reported here.

**Assessment of Testosterone and Cortisol**

After mixing and centrifuging samples, testosterone and cortisol were assayed in duplicate from clear salivary fluid using radioimmunoassay kits distributed by Diagnostic Systems Laboratories with modified procedures for saliva (Granger et al. 1999). Saliva samples taken during the lab session
were collected at various times of day; second saliva samples were all collected in the morning upon waking. Levels of both hormones were adjusted for linear and quadratic effects of time since waking to control for diurnal variation. Assay performance of both oxidative stress and salivary steroid measures are described elsewhere (Gangestad et al., 2010).

RESULTS

Covariates. Oxidative stress is affected by certain environmental toxins, such as heavy metals and cigarette smoke (e.g., Franco et al., 2009). In the current study, self-reported regular exposure to toxins (such as in the workplace, e.g., inhalation of fumes or car exhaust) predicted oxidative stress, \( r(71) = .26, p = .027 \), as did number of cigarettes smoked daily, \( r(70) = .26, p = .031 \). These confounds were controlled in all analyses.

Did relationship quality predict oxidative stress levels? Yes. With the two environmental confounds controlled, a robust negative association between oxidative stress with Expressive/Nurturing relationship quality emerged, \( r(36) = -.38, p = .020 \). (See Figure 1; Supplementary file.) Separate analyses of self- and partner- EN revealed Similar results: \( r(36) = -.37, p = .023 \), and \( r(36) = -.34, p = .036 \), respectively.

The associations between the full Partner-Specific Investment Inventory (aggregated across self and partner) and oxidative stress was slightly weaker yet significant, \( r(36) = -.33, p = .043 \).

Controlling for self-reports of quality of diet, current infection, or levels of physical exercise did not affect results. With all three controlled, \( r \) between oxidative stress and EN = -.37, \( p = .028 \).

Relationship length did not covary significantly with oxidative stress, \( r = -.02, ns. \)

Did testosterone or cortisol mediate the association between relationship quality and oxidative stress levels? No. Within the subsample of men in relationships, oxidative stress minimally covaried with testosterone, \( r(36) = .08, p = .643 \), and cortisol, \( r(36) = .06, p = .700 \). EN predicted neither
testosterone ($r(38) = -.01, p = .926$) nor cortisol ($r(38) = -.13, p = .421$).

**Relationship status.** We also examined whether relationship status was robustly associated with men’s oxidative stress in the total sample. It was not, $t(66) = .12, p = .72, \text{eta} = .04$, consistent with the idea that relationship qualities, beyond being in a relationship per se, afford health benefits.

**Separate biomarkers of oxidative stress.** Analyses of separate biomarkers revealed strong and robust associations with 8-OHdG: for aggregate EN, $r(36) = -.45, p = .005$; with diet, exercise, and current health partialled out, $r(33) = -.45, p = .006$. By contrast, correlations with MDA were uniformly in the same direction, but not significant ($-.11$ to $-.14$). Nonetheless, the two measures of oxidative stress covaried ($r(95) = .26, p = .012$), and the difference between correlations of the two biomarkers with aggregate EN fell short of statistical significance ($-.45$ vs. $-.12$), $\zeta = 1.67, p = .096$.

**DISCUSSION**

In a sample of romantically involved men, greater levels of expressing and sharing feelings in a relationship, being nurturing to one's partner, and feeling nurtured by them were associated with lower levels of oxidative stress. These findings constitute provisional evidence that oxidative damage partly explains the association between relationship quality and long-term health.

Naturally, relationship quality need not causally impact oxidative stress. A factor predisposing low oxidative stress may also predispose emotional nurturance. Though we cannot rule out that individual difference factors account for the association, another plausible interpretation is that relationship quality affects oxidative stress. The experience of being in an emotionally supportive relationship may directly affect levels of oxidative damage.

We examined two possible hormonal mediators, cortisol and testosterone, and found no evidence for either. Possibly, another hormone mediates the association. Oxytocin is a candidate, as it appears to have antioxidant effects (e.g., Szeto et al., 2008). Alternatively, our measures of cortisol
and testosterone, which show substantial short-term fluctuations, may not adequately capture the influences that long-term exposures have on oxidative stress.

The association with emotional nurturance was particularly strong for 8-OHdG, possibly because it better reflects oxidative damage in this young sample (e.g., Mayne, 2003) or because DNA oxidative damage and lipid peroxidation are sensitive to partially overlapping vulnerabilities (e.g., Sakano et al., 2009). Nonetheless, associations with MDA were not significantly weaker.

This study offers the first documentation that oxidative stress covaries with relationship quality, presenting an avenue for further investigation. Despite its limitations (the sample size is modest; oxidative stress levels was sampled on just two occasions; the study was not longitudinal; the study did not include women), it offers a clear empirical foundation on which to build.

In sum, a large body of research has linked positive romantic interactions with lower morbidity and mortality, but the physiological processes underlying effects remain poorly understood. Meanwhile, literature on oxidative stress fosters a nuanced understanding of the physiological underpinnings of senescence and disease. More generally, evolutionary biologists have come to see oxidative stress as a key player in the trade-offs between organisms’ somatic maintenance and other important life activities, including reproduction. Bridging these literatures, the current research offers theoretically rich avenues for further explorations into the physiological pathways by which psychological effects impact human health.

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