Journal of Family Psychology
2012, Vol. 26, No. 2, 290–295


0893-3200/12/$12.00 DOI: 10.1037/a0026902

BRIEF REPORT

# Marital Adjustment and Interleukin-6 (IL-6)

Mark A. Whisman
University of Colorado Boulder

David A. Sbarra
University of Arizona

Building on prior research that marital functioning is associated with a variety of health outcomes, we evaluated the association between marital adjustment and a marker of inflammation in a sample of married adults between the ages of 35 and 84 years old ($N = 415$) from the second wave of the population-based Survey of Midlife Development in the United States (MIDUS II). Specifically, we evaluated associations between positive (i.e., partner support) and negative (i.e., partner strain) dimensions of marital adjustment and interleukin-6 (IL-6) separately for men and women, and whether these associations were moderated by age. Results indicated that (a) marital adjustment was not associated with IL-6 in men, (b) age moderated the association between marital adjustment and IL-6 in women, (c) partner support and partner strain were associated with IL-6 in younger women, and (d) partner support but not partner strain was uniquely associated with IL-6 in younger women. The associations between marital adjustment and IL-6 in younger women were significant when controlling for demographic variables, health status indicators, health behaviors, depressive symptoms, and perceived stress. These findings suggest that IL-6 may be a useful biomarker for studying health-relevant biological responses within intimate relationships, and that young women, in particular, may exhibit increased inflammation when partner support is low.

*Keywords:* inflammation, interleukin-6, IL-6, marital adjustment, health

Marital adjustment is associated with a variety of health outcomes, including self-reported health, pain, and onset and outcome of specific diseases (for a review, see Kiecolt-Glaser & Newton, 2001). Kiecolt-Glaser and Newton (2001) proposed several potential pathways by which marital adjustment may impact health. Specifically, they proposed that positive and negative dimensions of marital adjustment are independent predictors of physical functioning, directly and indirectly (through health habits and psychiatric symptoms and syndromes) impacting biological systems (e.g., cardiovascular, endocrine, and immune systems), which in turn impact functional status and pathophysiology. These authors also hypothesized gender differences in patterns of physiological functioning and health, namely that marital functioning would be more strongly associated with health outcomes for women than for men. This hypothesis derives from gender-linked individual differences in relational traits and self-processes (Cross & Madson, 1997) and gender differences in stress exposure that occur in the context of marital roles (Glass & Fujimoto, 1994). Finally, they proposed that marital adjustment would be more strongly associated with health in older couples relative to younger couples because there are greater immunological impairments related to stress in older adults.

One biological process that may be associated with and potentially impacted by marital adjustment is inflammation (Kiecolt-Glaser, Gouin, & Hantsoo, 2010). In the past decade, a large body of research has demonstrated that inflammation—one of the body's main responses to removing potentially harmful pathogens and heal injuries—can become chronic and result in poor health if maintained over time (e.g., Libby, Ridker, & Maseri, 2002). For instance, inflammation is believed to play a key role in the development of atherosclerosis, the thickening of the of artery walls due to the accumulation of fatty materials, and the progression of cardiovascular disease (Lloyd-Jones, Liu, Tian, & Greenland, 2006). Proinflammatory cytokines are signaling molecules within the immune system that play an important role in coordinating inflammatory responses (Maier & Watkins, 1998). Within the large group of cytokines, interleukin-6 (IL-6) has emerged as an important correlate of psychological functioning, especially psychological stress and depressed mood (see Kiecolt-Glaser, McGuire, Robles, & Glaser, 2002; Miller & Blackwell, 2006; Raison, Capuron, & Miller, 2006; Segerstrom & Miller, 2004). Although the precise mechanisms through which psychological and/or social stress are associated with inflammation remain to be determined, considerable evidence indicates that psychosocial variables may impact endocrine, sympathetic, and autonomic nervous system functioning in ways that promote excessive inflammation (Hänsel, Hong, Cámara, & von Känel, 2010).

This article was published Online First January 9, 2012.

Mark A. Whisman, Department of Psychology and Neuroscience, University of Colorado Boulder, David A. Sbarra, Department of Psychology, University of Arizona.

This research was supported in part by grants from the National Alliance for Research on Schizophrenia and Depression awarded to Mark Whisman, and the National Science Foundation (BCS#0919525) and the National Institute of Aging (AG#036895) awarded to David Sbarra.

Correspondence concerning this article should be addressed to Mark A. Whisman, University of Colorado Boulder, Department of Psychology and Neuroscience, 345 UCB, Boulder, CO 80309-0345. E-mail: mark.whisman@colorado.edu

Despite the well-established associations between psychosocial variables and inflammation, relatively few studies, however, have explored the role of inflammation within relationships. Kiecolt-Glaser et al. (2005) examined cytokine responses among 42 healthy married couples in the morning following a marital disagreement interaction task; couples who discussed their marital disagreements in a hostile manner evidenced larger increases in plasma IL-6 the morning after the disagreement. Davis et al. (2008) found that chronic interpersonal stress (assessed daily over 30 days) was associated with IL-6 production among 58 patients with rheumatoid arthritis. In a sample of 109 healthy women, Miller, Rohleder, and Cole (2009) found that chronic interpersonal stress was associated with an increase in IL-6 six months later. Other research shows that a more general measure of positive social relationships, a key dimension of psychological well-being, is associated with significantly lower IL-6 production in a sample of older women (Friedman et al., 2005), and partner support has been linked with other biomarkers of health (e.g., Grewen, Girdler, Amico, & Light, 2005). In sum, a small but growing literature indicates that IL-6 levels covary with the quality of social relationships and, in particular, that hostile marital interactions may provoke potent IL-6 responses.

The paucity of research on relationships and inflammation is noteworthy given that relationships, and especially intimate relationships such as marriage, provide a critical context in which many of our strongest emotions unfold. Our most positive *and* negative emotional experiences often unfold in relationships, and, in this respect marriage has the potential to protect against or potentiate adverse biological responses that are associated with psychosocial stress. Given this perspective, the present study was conducted to evaluate the cross-sectional association between marital adjustment and IL-6. In doing so, we approached this topic by evaluating some of the hypotheses advanced by Kiecolt-Glaser and colleagues (Kiecolt-Glaser et al., 2010; Kiecolt-Glaser & Newton, 2001). We hypothesized that marital adjustment would be associated with IL-6, at least for women. We examined the associations between IL-6 and both positive and negative aspects of marital adjustment and we evaluated whether the associations between marital adjustment and IL-6 were moderated by age; Kiecolt-Glaser and Newton (2001) predicted that relationship discord should be more highly associated with immunological impairments among older couples. Finally, we evaluated whether marital adjustment was associated with IL-6 controlling for variables have been shown to covary with inflammation outcomes, including demographic variables, medication usage, health status indicators, health behaviors, depressive symptoms, and perceived stress (for a review, see O'Connor et al., 2009).

## Method

### Participants

Participants were drawn from the National Survey of Midlife Development in the United States (MIDUS), which is a population-based study of noninstitutionalized adults living in the 48 contiguous United States who were recruited through random digit dialing. Participants completed telephone and mail surveys in 1995–1996 (MIDUS) and 2004–2006 (MIDUS II). Biological data were collected on a subset of MIDUS II participants (Ryff, Seeman, & Weinstein, 2010). As described in greater detail by Morozink, Friedman, Coe, and Ryff (2010), to be eligible, respondents had to complete the telephone and mail surveys and be able and willing to travel to one of three General Clinical Research Centers (GCRC) for an overnight visit. Of those invited to participate, 43% agreed. The primary reasons for refusal were not wanting to travel to the clinic, having other obligations, or being too busy. Participants completed a 2-day visit to a GCRC, during which they provided a complete medical history and medication information, underwent a physical exam with a physician, and provided a fasting blood draw around 0700 on the morning of the second day. The blood sample was obtained prior to any caffeine or nicotine consumption for the day. The present analyses are based on 228 men and 187 women who were married, members of the original core sample, and who participated in the biological data collection. Demographic data for the sample are presented in Table 1.

### Measures

**IL-6.** As described by Morozink et al. (2010), serum IL-6 was measured using Quantikine high-sensitivity enzyme-linked immunosorbent assay according to manufacturer guidelines (R&D Systems, Minneapolis, MN). The laboratory intraassay coefficient of variance was 4.09% and the interassay coefficient of variance was 13%. The distribution of IL-6 scores was positively skewed and log-transformed to approximate a more normal distribution.

**Marital adjustment.** Marital adjustment was measured by six supportive interaction items (*partner support*; e.g., How much do they [your spouse] really understand the way you feel about things?) and six negative interaction items (*partner strain*; e.g., How much do they criticize you?) items. Briefer scales consisting of these items correlate highly (i.e., $> |.45|$) with other measures of dyadic adjustment and dyadic satisfaction (Whisman & Li, 2011). Items were rated on a 4-point scale, and partner support and partner strain scales were constructed by calculating the mean of the items, with higher scores reflecting higher standing on each scale. Research with the MIDUS data indicated items on these scales loaded onto two distinct but correlated factors (Walen & Lachman, 2000). Good internal consistency was found for the support ($\alpha = .91$) and strain ($\alpha = .88$) scales in the present sample.

**Covariates.** We included as covariates demographic variables, medication usage, health status indicators, health behaviors, depressive symptoms, and perceived stress; these variables have been shown to covary with inflammation outcomes (for a review, see O'Connor et al., 2009) and were included in the MIDUS data set. Participants were asked their highest level of educational attainment and responses were used to create an ordinal variable with three categories (up to high school, some college, college graduate). Dummy-coded variables were used to indicate obesity ($\geq 30$ kg/m$^2$ based on height and weight as measured by GCRC staff) and the use of medications that have anti-inflammatory properties (i.e., blood pressure medication, cholesterol medication, corticosteroid medication, depression medication). A continuous measure of chronic health conditions was computed as a sum of self-reported physician diagnosed conditions, including heart disease, high blood pressure, circulation problems, blood clots, heart murmur, transient ischemic attack or stroke, anemia or other blood disease, cholesterol problems, diabetes, asthma, emphysema or chronic obstructive pulmonary disease, tuberculosis, thyroid dis-

Table 1
*Descriptive Information for IL-6, Demographic Variables, Medication Usage, Health Status, Health Behaviors, Depressive Symptoms, Perceived Stress, and Marital Adjustment*

| | Men | | | Women | | |
|---|---|---|---|---|---|---|
| Variable | % | Mean | *SD* | % | Mean | *SD* |
| IL-6 | | 2.77 | 2.86 | | 2.33 | 2.10 |
| Age | | 57.60 | 11.63 | | 55.20 | 11.05 |
| White | 91.4 | | | 93.3 | | |
| Education | | | | | | |
| High School graduate, GED, or less | 36.9 | | | 31.1 | | |
| Some college | 24.7 | | | 26.7 | | |
| College graduate | 38.3 | | | 42.2 | | |
| Blood pressure medication | 34.2 | | | 33.1 | | |
| Cholesterol medication | 33.3 | | | 22.6 | | |
| Corticosteroid medication | 3.9 | | | 20.2 | | |
| Depression medication | 10.2 | | | 16.9 | | |
| Obesity | 41.8 | | | 37.9 | | |
| Chronic health conditions | | 1.96 | 2.55 | | 2.65 | 2.46 |
| Current smoker | 15.8 | | | 6.3 | | |
| Lifetime smoker | 53.8 | | | 37.2 | | |
| Alcohol consumption | | | | | | |
| No alcohol consumption | 26.3 | | | 38.6 | | |
| Moderate alcohol consumption | 52.1 | | | 34.5 | | |
| Heavy alcohol consumption | 21.5 | | | 26.9 | | |
| Depressive symptoms | | 7.75 | 7.07 | | 8.09 | 7.23 |
| Perceived stress | | 21.76 | 5.92 | | 22.85 | 5.89 |
| Partner support | | 3.67 | 0.50 | | 3.56 | 0.61 |
| Partner strain | | 2.16 | 0.64 | | 2.15 | 0.65 |

ease, peptic ulcer disease, cancer, colon polyps, arthritis, glaucoma, cirrhosis or liver disease, or depression; this variable has been used as a covariate by other researchers studying IL-6 with the MIDUS II data (e.g., Morozink et al., 2010). Dummy coding was used to indicate whether the person currently smoked cigarettes regularly or had ever done so in their lifetime, and alcohol consumption was an ordinal variable reflecting participants' consumption during the past month [0 = *no consumption*, 1 = *moderate drinking (up to two drinks per day for men and one drink per day for women)*, 2 = *heavy drinking (more than moderate drinking)*]. Finally, depressive symptoms were assessed by the Center for Epidemiological Studies Depression scale (Radloff, 1977), and the Perceived Stress Scale (Cohen, Kamarck, & Mermelstein, 1983) was used to measure participants' perception of the degree to which situations in their lives were appraised as stressful; good internal consistency was obtained for the CES-D ($\alpha = .87$) and PSS ($\alpha = .86$) in the current sample. Data on marital adjustment and the covariates were collected during MIDUS II.

## Results

To evaluate whether the association between marital adjustment and IL-6 was moderated by age, multiple regression analyses were conducted, with IL-6 regressed on age, marital adjustment, and the Age × Marital Adjustment interaction term, with age and marital adjustment mean-centered (Whisman & McClelland, 2005); separate multiple regression analyses were run for partner support and partner strain. We conducted all analyses separately for men and women because the power to detect three-way Age × Marital Adjustment × Gender was low. In particular, the power to detect the three-way effect for marital support was .20 and the power to detect the three-way effect for marital stain was .49. If the main or moderated association between marital adjustment and IL-6 was significant, we would then reconduct the regression analyses, controlling for demographic variables, medication usage, health status indicators, health behaviors, depressive symptoms, and perceived stress.

Results for men indicated that after controlling for the component terms, the Age × Marital Adjustment interaction term was not significant for either partner support, $b = .00$, $p = .87$, or partner strain, $b = .00$, $p = .62$. Thus, there was no evidence that the association between marital adjustment and IL-6 was moderated by age for husbands. To evaluate the bivariate association marital adjustment and IL-6 in men, Pearson correlations were computed. Results indicated that neither support ($r = .11$, $p = .14$) nor strain ($r = -.05$, $p = .52$) were significantly associated with IL-6 for men.

Results for women indicate that after controlling for the component terms, the Age × Marital Adjustment interaction term was significant for partner support, $b = .01$, $p = .05$, and partner strain, $b = -.01$, $p = .02$. We then evaluated whether the Age × Marital Adjustment interaction terms were significantly associated with IL-6 when additionally controlling for demographic variables, medication usage, health status indicators, health behaviors, depressive symptoms, and perceived stress. Thus, the regression analyses were conducted with these covariates added (see Table 2). Results indicated that after controlling for the component terms and the set of covariates, the Age × Marital Adjustment interaction term was significant for partner support, $b = .01$, $p = .01$, and partner strain, $b = -.01$, $p = .02$. To probe these interactions, we used the Johnson and Neyman (1936) procedure to identify the

Table 2
*Unstandardized Regression Coefficients From Regression Analyses Predicting IL-6 in Women*

| | All women | | Younger women |
|---|---|---|---|
| Predictor variable | Support | Strain | |
| Age | .01** | .01** | .01 |
| White | .04 | .06 | .16 |
| Education | .04 | .04 | .03 |
| Blood pressure medication | .07 | .05 | .09 |
| Cholesterol medication | −.02 | −.02 | −.08 |
| Corticosteroid medication | −.07 | −.05 | −.09 |
| Depression medication | .16* | .13* | .10 |
| Obesity | .13** | .13** | .27** |
| Chronic health conditions | .01 | .01 | .00 |
| Current smoker | −.05 | −.06 | .03 |
| Lifetime smoker | −.04 | −.02 | −.05 |
| Alcohol consumption | .00 | −.00 | .01 |
| Depressive symptoms | −.00 | .00 | −.01 |
| Perceived stress | −.00 | −.00 | .01 |
| Partner support | −.06 | | −.15* |
| Partner strain | | .06 | .03 |
| Age × Support | .01** | | |
| Age × Strain | | −.01* | |
| | $R^2 = .25$, $F = 3.38$, $p < .001$ | $R^2 = .24$, $F = 3.31$, $p < .001$ | $R^2 = .36$, $F = 2.40$, $p < .01$ |

* $p < .05$. ** $p < .01$.

region of significance, the boundary of which is the specific value of the moderator (i.e., age) at which the regression of the outcome variable (i.e., IL-6) on the predictor variable (i.e., marital adjustment) passes from significance to nonsignificance at a selected α. Using an α of .05, results indicated that holding the other variables constant, partner support and partner strain were significantly associated with IL-6 up until age 53. To evaluate whether positive and negative dimensions of marital adjustment were uniquely associated with IL-6, we selected women who were ≤ 53 years of age, and conducted a linear regression analyses with this subset of women, regressing IL-6 on partner support and partner strain, after controlling for the covariates. Results indicate that after controlling for the set of 14 covariates, $R^2 = .25$, $F(14, 71) = 1.67$, $p = .08$, the two marital adjustment variables accounted for an additional 11% of the variance in IL-6 among younger women, $F(2, 69) = 5.94$, $p < .01$; IL-6 was uniquely associated with partner support, $sr = -.20$, $p = .04$, but not partner strain, $sr = .04$, $p = .67$; the final model is presented in Table 2. IL-6 was uniquely associated with partner support despite the strong correlation between partner support and partner strain ($r = -.70$, $p < .001$).

## Discussion

The present study was conducted to evaluate the association between two aspects of marital functioning—partner support and partner strain—on a marker of inflammation (i.e., IL-6) in a sample of married women and men, and to examine whether age moderated these associations. The primary findings were that (a) marital adjustment was not associated with IL-6 in men, (b) age moderated the association between marital adjustment and IL-6 in women, (c) partner support and partner strain were associated with IL-6 in younger women, and (d) partner support but not partner strain was uniquely associated with IL-6 in younger women. Furthermore, the associations between marital adjustment and IL-6 in women were significant when controlling for demographic variables, health status indicators, health behaviors, depressive symptoms, and perceived stress. Given these findings, it is reasonable to speculate that inflammation may be one biological mechanism through which marital adjustment affects health outcomes. For example, a low frequency of positive partner exchanges (i.e., low partner support) or a high frequency of negative partner exchanges (i.e., high partner strain) could lead to elevated IL-6, which in turn could increase risk for cardiovascular disease; excessive inflammation could also increase risk for other diseases through processes such as glucocorticoid sensitivity (Kiecolt-Glaser et al., 2010).

The association between partner support and partner strain and IL-6 in younger women remained significant when controlling for demographic variables, health status indicators (i.e., obesity, chronic health conditions), health behaviors (smoking status, alcohol consumption), psychiatric (i.e., depressive) symptoms, and perceived stress. Therefore, it appears that the associations between marital adjustment and IL-6 in younger women cannot be reduced to these factors. In particular, because marital adjustment was measured with a self-report questionnaire, the finding that partner support and partner strain were associated with IL-6 when controlling for self-rated depressive symptoms and perceived stress suggests that this association is not just due to participants' level of distress or demoralization but rather something specific to the marital relationship. However, health status and health behaviors were measured with simple, global measures that may not provide adequate assessment of these constructs. In future research, it would be important to include well-validated measures of these constructs, to fully control for their shared association with marital adjustment and IL-6.

Kiecolt-Glaser and colleagues (Kiecolt-Glaser et al., 2010; Kiecolt-Glaser & Newton, 2001) proposed that positive and negative aspects of marital adjustment would be uniquely associated with psychophysiology and health. Although both positive and negative exchanges were associated with IL-6 in separate analyses, when both partner support and partner strain were simultaneously entered into the analysis predicting IL-6 in younger women, only positive functioning (i.e., partner support) was uniquely associated with IL-6. Researchers evaluating supportive interactions in marriage have focused on interactions in which partners talk about something they would like to change about themselves, with common topics including changes in health behaviors such as losing weight and dealing with stress (Pasch & Bradbury, 1998). Perhaps low partner support makes it difficult to initiate (and possibly maintain) health-promoting behavior among women, increasing the likelihood of greater inflammation and poor health.

Kiecolt-Glaser and Newton (2001) hypothesized that marital adjustment may be more strongly associated with health in older couples relative to younger couples because there are greater immunological impairments related to stress in older adults. In comparison, however, we found that marital adjustment was more strongly associated with IL-6 in younger women. It may be that supportive interactions are particularly important for younger women because relative to older women, they are have greater responsibility for and participate in domestic chores that result in stronger associations between marital adjustment and physiological responses; prior research has found age differences in certain kinds of stressful events, as well as in the ways people cope with such events (e.g., Folkman, Lazarus, Pimley, & Novacek, 1987). Alternatively, the presence of negative partner behavior and the absence of positive partner behavior may be more predictable and, therefore, less stressful for older women involved in long-term relationships relative to younger women, resulting in weaker associations between support, strain, and IL-6 in older women. It is important to note, however, that we evaluated the moderating role of age on the association between self-reported marital adjustment and IL-6. As such, we did not evaluate whether stress-related physiological responses have greater health consequences for older spouses than for younger spouses.

In interpreting the results from this study, it is important to keep in mind several limitations. First, the cross-sectional design of the study limits the conclusions that can be made regarding the etiological significance of the findings. Longitudinal research, involving multiple assessments of marital adjustment and IL-6, is needed to determine whether marital adjustment as an antecedent, correlate, or consequence of IL-6. Research has shown that marital functioning is associated with longitudinal changes in other biomarkers of health (e.g., Whisman & Uebelacker, 2011), and similar research with IL-6 is needed to examine whether marital adjustment is a precursor of inflammation. Second, the sample size was too small to evaluate whether gender moderated the association between marital adjustment and IL-6. Our findings regarding different results between women and men should be interpreted as suggesting that marital adjustment is associated with IL-6 for women but not men, but it cannot be concluded that gender moderates the magnitude of this association. Third, the sample was predominately White, and additional research with a more diverse sample is needed. Fourth, we were not able to test all aspects of Kiecolt-Glaser and colleagues' (2010) model of inflammation in marriage. For example, other individual differences (e.g., hostility), other health behaviors (e.g., eating habits), or other psychiatric symptoms or syndromes may be important to consider in a comprehensive model of marriage and health. In addition, the MIDUS sampling strategy prevented us from studying real-time, proximal associations between marital adjustment and IL-6, which was done in prior studies (e.g., Kiecolt-Glaser et al., 2005). In this respect, stress and strain are conceptualized and operationalized as relatively global constructs, which are likely to unfold in the context of daily interactions with one's partner. When considering the findings reported here, it is important to recognize that we report effects for global indicators of partner support and partner strain and not observed interaction patterns.

These limitations notwithstanding, the results from this study suggest that marital adjustment, particularly partner support, is associated with IL-6 in younger women, and that the association between marital adjustment and IL-6 is incremental to several variables that covary with inflammation outcomes (O'Connor et al., 2009). This finding suggests that inflammation may play an important role in the pathophysiology of health in couples and that IL-6, in particular, is a useful biomarker for studying health-relevant biological responses within relationships. If future research finds that poor marital adjustment predicts changes in IL-6 over time, then, improving marital adjustment, particularly through improving partner support, may result in lower inflammation and better health outcomes, particularly for younger married women.

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Received July 18, 2011
Revision received December 5, 2011
Accepted December 7, 2011 ■