Frequency of Spousal Interaction and 3-Year Progression of Carotid Artery Intima Medial Thickness: The Pittsburgh Healthy Heart Project

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Objective: We employed Ecological Momentary Assessment (EMA) real-time recording in the natural setting to determine whether spousal interaction frequency predicts 3-year progression of carotid artery intima medial thickening (IMT). **Methods:** Participants were 250 healthy, older adults (*M* age = 61, 48% female) who, at baseline, underwent 6 days of ambulatory monitoring using electronic diaries to collect data on mood, activity, and posture, as well as current or recent (past 10 minutes) social interactions. Participants also underwent ultrasound imaging of the carotid arteries at baseline and 3-year follow-up. Spousal interaction frequency was computed as the sum of total interactions with only the spouse during the 6 days of monitoring. **Results:** Spousal interaction frequency did not predict IMT change in the sample as a whole ($p = .87$). However, a sex by spousal interaction by marital adjustment interaction ($p = .02$) indicated that more frequent spousal interaction was associated with less IMT progression among men with better marital adjustment ($p = .03$). In contrast, frequent spousal interaction predicted greater IMT progression among women with better martial adjustment ($p < .01$). This effect lost significance when women's total social interactions (sum of all interactions) were included in the model. Total social interaction frequency was an independent predictor of IMT among women but not men. **Conclusions:** These findings extend those of previous research by suggesting that frequent spousal interactions may be associated with long-term cardiovascular health among happily married older men and demonstrate how sampling daily experience may enhance our understanding of the possible health benefits of marriage. **Key words:** cardiovascular disease, ecological momentary assessment, intima medial thickness, marital adjustment, spousal interaction.

ABP = ambulatory blood pressure; **BP** = blood pressure; **CVD** = cardiovascular disease; **EMA** = ecological momentary assessment; **IMT** = intima medial thickness; **SES** = socioeconomic status; **DAS** = Dyadic Adjustment Scale; **LVM** = left ventricular mass; **PHHP** = Pittsburgh Healthy Heart Project; **DABS** = Diary of Ambulatory Behavioral States; **ARIC** = Atherosclerosis Risk in Communities; **SNQ** = Social Network Questionnaire.

INTRODUCTION

In addition to the well-established health benefits associated with being married (1), there is evidence to suggest that the quality of the marital relationship may be associated with reduced cardiovascular disease (CVD) risk among married persons. Two recent studies have shown that worse marital adjustment was associated with less successful CVD recovery in hospitalized samples (2,3). Among married women who had been hospitalized for CVD, marital stress at hospital intake was associated with increased risk of a recurrent event at 5-year follow-up (3). Similarly, among hospitalized men and women with congestive heart failure, marital adjustment assessed at hospital intake predicted survival 4 years later. Gender moderated this association, however, such that the detrimental effect of poor marital quality was stronger among women relative to men (2).

Though compelling, the above findings must be interpreted with caution due to certain limitations inherent in data obtained from persons with preexisting disease. Most notably, one cannot exclude the possibility that existing CVD may influence scores on psychosocial measures. With specific regard to the findings reported by Coyne et al. (2) and Orth-Gomer et al. (3), it cannot be known whether marital distress was an antecedent of disease or whether CVD anticipated a decline in marital adjustment.

One strategy that has been employed to circumvent this type of causal confound is the inclusion of subclinical disease measures as proxies for CVD end points. Assessments of carotid artery atherosclerosis, for example, have been gaining favor among investigators of psychosocial correlates of CVD. Measures of subclinical carotid atherosclerosis have been identified as independent risk factors for symptomatic disease (4). Carotid artery intima medial thickness (IMT), specifically, has been found to be an independent correlate of future myocardial infarction and stroke among older adults (5).

To date, only one known study has investigated whether marital adjustment is associated with change in subclinical CVD among healthy persons. Gallo and colleagues (6) examined progression of carotid artery atherosclerosis in a sample of healthy, postmenopausal women. Results showed a cross-sectional association between better marital satisfaction and less atherosclerosis when assessed at 11-year follow-up. Moreover, marital satisfaction at baseline was associated with less rapid disease progression during the 3 years between the 11- and 14-year assessments (6).

Taken together, the findings from the above three studies suggest that cardiovascular health benefits associated with marriage may be amplified among those whose marriages are well adjusted. Nevertheless, it is yet unknown which psychological and physiologic factors may mediate this relation.

Spousal interaction may be one mechanism by which marital quality is translated into physical health benefits. In a cross-sectional study, Baker and colleagues (7) found lower scores on the Cohesion subscale of the Dyadic Adjustment Scale (DAS) (8) to be associated with elevated nighttime ambulatory blood pressure (ABP). Among those with Cohe-

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sion scores below the sample mean, more frequent spousal contact (as reported in end-of-day diaries) was associated independently with higher ABP. Gender did not moderate these results (7). In a later study, Baker and colleagues (7,9) investigated the association between 3-year ABP change and left ventricular mass (LVM) among participants who were employed in the investigation previously described (7). Total DAS score predicted LVM change over time but not change in ABP. However, there was a significant moderating effect of frequency of spousal contact on 3-year change in mean 24-hour diastolic ABP: Among persons with lower baseline scores on the Satisfaction subscale of the DAS, more spousal contact was associated with elevations in ABP over time; the reverse relation was found for persons who scored higher on baseline Satisfaction. Among these individuals, more frequent spousal contact was associated with a relative decline in mean diastolic ABP 3 years later. Once again, these findings were independent of gender (9).

The findings of Baker and colleagues (9) are complemented by those from a second study that employed ambulatory monitoring to examine the influence of daily social interactions on ABP among healthy, married, and cohabiting adults (10). In this sample, better marital quality was associated with more spousal interactions, and spousal interactions were associated with lower concurrent systolic ABP relative to interacting with any one other person or while not interacting (10). An advantage of the latter study (10) was the application of ecological momentary assessment (EMA)—real-time recording in subjects' natural environments (11)—via an ambulatory diary to collect reports of spousal interaction frequency. By comparison, Baker and colleagues (9) derived their measure of spousal contact from retrospective, end-of-day reports. End-of-day assessments, like other retrospective measures, may be subject to recall bias (12). Because momentary diaries like the one employed by Gump et al. (10) involve subjects' reporting on events in nearly real time, the risk of recall bias is significantly reduced (11).

In sum, the above reviewed literature suggests (1) better marital quality is associated with better survival outcomes among persons with CVD; (2) better marital quality appears to be protective against progression of subclinical CVD among healthy women; (3) marital adjustment and frequent spousal interaction appear to have a synergistic effect on ABP, such that persons in well-adjusted marriages who interact frequently with their spouses show the lowest blood pressures (BPs). Though the collective findings of these studies are consistent insofar as they suggest that a generally positive marital experience may be associated with cardiovascular health benefits, a number of unanswered questions remain. First of all, as previously discussed, the findings reported by previous studies of marital quality and hard CVD outcomes are limited in that they were conducted among hospitalized CVD patients (2,3). Gallo et al. (6) ruled out the possibility of reverse causation by employing a healthy sample and assessing subclinical CVD. The generalizability of this study is somewhat limited, however, as the sample consisted entirely of women. Baker et al. (9) and Gump et al. (10) also employed sample populations that were free of clinical CVD and included both men and women. In this way, the combined effects of marital adjustment and spousal interaction frequency on ABP reported by these two studies confirm that the findings reported by Gallo et al. (6) may generalize to men. However, though ABP may be a risk factor for future CVD, it does not index extent of existing subclinical disease. Thus, it still is unknown whether marital adjustment and spousal interaction frequency may have a synergistic effect on progression of subclinical CVD.

The goal of the present study is to expand the ABP findings reported by Baker et al. (9) and Gump et al. (10) by examining whether EMA diary reports of spousal interaction frequency are associated with subclinical CVD progression among a sample of healthy, older adults. Our expectations were that (1) more frequent spousal interactions would be associated with less subclinical disease progression over time; and (2) there would be a synergistic effect of spousal interaction frequency and marital adjustment such that frequent spousal interactions are especially protective among persons with better marital adjustment. As the extant literature is inconsistent regarding the association between marital adjustment and CVD outcomes, we made no prediction regarding this relation in the present sample.

Results from a sizable literature suggest that the health benefits associated with married status appear to be stronger among men relative to women (1). By comparison, the only known study to report sex differences in the effects of marital adjustment on CVD outcomes found the association to be stronger for women than for men (2). Taken together, these findings suggest that whereas men's health may benefit from the *fact of being married*, women's health may suffer when the *quality* of the marriage is low. Because of these apparent sex differences in the effects of marriage variables on health, we explored whether sex acts as a moderator of the associations proposed above. Our expectation was that (1) any association between marital adjustment and subclinical CVD would be stronger among women relative to men; and (2) more frequent spousal interactions would predict enhanced subclinical disease progression among women with worse marital adjustment.

METHODS

Participants

The sample of 250, healthy older persons (mean age = 60.7; range = 50.0 to 70.8), was a subset of participants in the Pittsburgh Healthy Heart Project (PHHP). The larger study is a longitudinal investigation of the effects of psychosocial and biological risk factors on subclinical CVD in a community sample. The PHHP received approval of the institutional review board at the University of Pittsburgh. Participants provided written informed consent to all procedures and were paid $350 for the portions of the study described here. Recruitment strategies included targeted mailings and media postings in the Pittsburgh metropolitan area. Major inclusion criteria were age (50–70 years) and menopausal status (women were required to be peri- or postmenopausal, defined as absence of menstruation during the 6 months before enrollment). Individuals were excluded from the study if they reported a history of CVD or other chronic disease (including diabetic persons who take insulin), use of antihypertensive or lipid-lowering medication, or premenopausal status. Persons with screening BPs ≥180/110, as well as persons with a pattern of excessive alcohol consumption (≥5 portions three or more times a week) also were excluded from the PHHP.

Participants from the larger study were included in the present report if they were (a) married, or reported having a spousal equivalent; (b) had completed a self-report measure of marital adjustment; (c) provided at least 30 valid diary readings across each of two 3-day assessment periods (see Procedure); and (d) had complete ultrasound carotid atherosclerosis data.

The subsample described herein was 47.6% female and 8.4% nonwhite. Participants represented all levels of educational attainment, with 24.8% of the sample having completed high school or less and 51.2% having completed a bachelor's or more advanced degree. This distribution of educational attainment indicates that the sample was, in general, more highly educated than the population as a whole. On average, participants had been married for 34.0 years.

Procedure

Overview

Figure 1 presents a flow diagram depicting the temporal sequence of procedures followed by PHHP participants. Following informed consent, baseline data collection procedures for the larger study involved 10 laboratory sessions that were scheduled over 5 months. These sessions included a medical screening visit, three visits involving training and feedback for an initial 3-day ambulatory monitoring period, a visit for cardiovascular reactivity testing (see (13) for details), a visit for baseline carotid artery ultrasound assessment, a visit for additional ultrasound measures (not reported here), and three visits associated with a second 3-day ambulatory monitoring interval. During the medical screening visit, data were collected on CVD risk factors such as height, weight, and smoking and alcohol use. In addition, blood samples were obtained for evaluation of other physiologic risk factors such as plasma cholesterol and triglycerides. Also during the initial visit, participants completed a demographic survey and a health behavior questionnaire. About 1 month later (mean = 36.5 days; range = 3.0 to 133 days), participants returned to the laboratory and were trained to use an electronic diary (see below) and automated ABP equipment (see (13,14) for details). Practice data collection in the field began on completion of training and continued until a feedback session that took place on the following day. During the feedback session, practice data were uploaded and reviewed by a research assistant, and any problems that occurred during monitoring were discussed. Actual data collection began the following morning and continued for a total of 3 days. Follow-up training and an additional 3 days of monitoring took place, on average, 3.7 months later (mean = 111.4 days; range = 59 to 325 days); procedures were nearly identical to those for baseline.

Approximately 2.5 months postenrollment (mean = 74.7 days; range = 14 to 312 days), participants attended the ultrasound research laboratory for baseline measurement for carotid atherosclerosis. About 3 years later (mean = 1100.66 days; range = 882 to 1444 days), participants returned for a follow-up ultrasound scan and additional medical screening for risk-factor status.

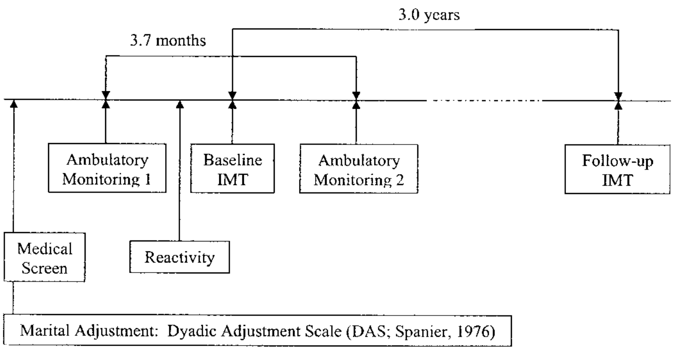

Figure 1. Procedure timeline.

Diary of Ambulatory Behavioral States (DABS)

Participants described recent social interactions using multi-item subscales from the DABS, a 45-item closed-ended questionnaire that was designed for repeated real-time assessment of behavioral and psychosocial influences on cardiovascular activity during daily life. DABS items address present mood, activities, recent consumption, and descriptive features of recent social interactions. As the present report focuses on change in carotid IMT over time, relations of DABS items to ambulatory cardiovascular activity will not be discussed (see (14,15) for details). DABS items were displayed and responses recorded by an electronic diary implemented on a palmtop computer (hardware: Palm Pilot Professional Handheld, Palm, Inc., Santa Clara, CA; software: Invivodata, Inc., Pittsburgh, PA). The diary precluded missing or out-of-range entries and time-stamped the resulting data records to ensure and document timely completion of the diaries. Respondents were prompted to enter data at 45-minute intervals during waking hours. Details on the validity of the DABS for assessing spousal interactions are available elsewhere (16).

Spousal Interactions

A social interaction was defined as a "give-and-take exchange with another, which may or may not involve conversation" (17). Spousal interactions were defined as those that (a) involved only the spouse and (b) took place concurrently or within 10 minutes of the diary report.[1] Spousal interaction frequency was computed as the total number of spousal interactions reported by participants in their electronic diaries over the 6 days of monitoring. The total number of social interactions (i.e., spouse + nonspouse) was computed as the sum of all social interactions that occurred within 10 minutes of the diary report. Quality of interactions was assessed using the following four DABS multi-item subscales: negative affect (4 items), social conflict (3 items), agreeableness (3 items), and intimacy (3 items). Component items were presented in the form of a visual analog scale wherein participants used a graphically displayed "slider" to indicate their responses (0–10 range). Subscale scores were averaged, in turn, across all available observations for each participant. The DABS previously has been found to be a reliable measure of social interaction frequency (r = 0.61, $p < .001$) and quality (agreeableness: r = 0.68, $p < .001$; conflict: r = 0.69, $p < .001$) in this sample across the 3.7 month follow-up period (16).

Marital Adjustment

Marital adjustment was assessed at baseline using the DAS (8), a 32-item self-report instrument that measures various aspects of marital function, with higher scores indicating better adjustment. The DAS showed excellent internal consistency when examined among the present sample (Cronbach's α = 0.94) (cf, (8)). Additional psychometric data on the DAS are reported elsewhere (18). DAS scores for the present sample ranged from 37 to 144, with 17.2% of the sample (n = 43) scoring in the "distressed" range (i.e., <100). The distribution of DAS was negatively skewed.

Additional Psychosocial Variables

During two baseline visits (see Figure 1), participants completed the following measures of psychosocial characteristics that were investigated in exploratory analyses as potential mediators of the association between spousal interactions and subclinical CVD progression. These instruments include the Beck Depression Inventory (19), the Beck Anxiety Inventory (20), the Buss-Perry Aggression Questionnaire (21), the Cook-Medley Hostility Scale (22), and the Social Network Questionnaire (SNQ) (23).

Carotid Atherosclerosis

Carotid artery IMT was used as the measure of subclinical CVD. Ultrasound images of the carotid arteries were obtained using Toshiba SSA-270A

[1]The DABS also included an item that asked about the medium through which the interaction was conducted (in person, telephone, e-mail). As most interactions took place in person (84.9%), this item was not included in analyses.

TABLE 1. Descriptive Sample Data

	Sample, $n = 250$, mean (SD)	Men, $n = 131$, mean (SD)	Women, $n = 119$, mean (SD)	Sex Difference, p
Number of spousal interactions	27.1 (15.0)	26.3 (14.23)	27.9 (15.8)	.40
Average DAS score	111.9 (17.0)	113.0 (15.9)	110.6 (18.1)	.28
Baseline mean IMT (mm)	0.77 (0.16)	0.80 (0.14)	0.73 (0.12)	<.001
Followup mean IMT (mm)	0.85 (0.22)	0.91 (0.19)	0.79 (0.16)	<.001
Average IMT change (mm)	0.08 (0.14)	0.11 (0.12)	0.06 (0.09)	.006

and SSA-140A scanners (Toshiba American Medical Systems, Tustin, CA). Use of ultrasound technology to examine the carotid arteries has been found to be a valid and reliable method for detecting subclinical disease (24,25); the noninvasive nature of ultrasound scanning makes it an appropriate procedure for use in asymptomatic populations. Optimal images of the first 1.0 cm of the right and left common and internal carotid arteries, as well as all measurable areas of the right and left carotid bifurcations (i.e., the bulb), were digitized for a period of 10 seconds for later scoring of IMT. An automated edge detection system (AMS, Goteborg University, Gothenburg, Sweden) was used to measure IMT within each of the artery segments described above. The automated system is preferable to manual methods as it has been shown to be associated with enhanced interrater reliability (26). Overall mean IMT was derived by taking the average of the six far-wall loci across both right and left carotid arteries. IMT progression was computed as the arithmetic difference between 3-year follow-up and baseline IMT scores. The distribution of IMT change scores was asymmetrical, so a natural log transformation was used to obtain an approximately normal distribution.

Data Analysis

All statistical analyses were conducted using the SAS statistical software package (Version 8; SAS Institute, Cary, NC). The GLM procedure was used to compute all of the main analyses; *t* tests were used for sex comparisons in predictor and criterion variables. As preliminary analyses indicated that baseline IMT, age, sex, and the age-by-sex cross-product term are associated with IMT change in the present sample, all of these variables were included as covariates in each of the models reported here.

RESULTS

On average, participants reported being in fairly well-adjusted marriages (mean DAS score = 111.9 ± 17.0), and engaging in an average of 27.1 ± 15.0 spousal interactions during the 6 days of monitoring. Participants showed modest carotid IMT, with an average increase of 0.08 mm during the 3 years of follow-up (baseline IMT = 0.77 ± 0.16 mm; follow-up IMT = 0.85 ± 0.22 mm). Table 1 displays descriptive data on predictor and criterion variables separately by sex. As indicated, men showed greater IMT than women at the first and second assessments, as well as greater 3-year IMT change. Normative data on IMT progression have been collected from the Atherosclerosis Risk in Communities (ARIC) study (27). Average IMTs for men and women from the present sample are larger than analogous data reported in ARIC (0.66–69 mm and 0.59–0.63 mm for men and women, respectively). Annualized progression rates from PHHP (0.03 mm/yr) also are somewhat larger than those shown in ARIC (0.007–0.01 mm/yr). It should be noted that ARIC employed a comparatively younger sample (ages 45–64) and examined only the common carotid artery (i.e., internal carotid artery and carotid bulb measurements were not included in the ARIC IMT index). Comparable common carotid data from the PHHP show an annualized change of 0.012 mm (men: 0.015 mm/yr; women: 0.007 mm/yr).

TABLE 2. Effects of Marital Quality, Spousal Interaction Frequency, and Their Interaction Terms on 3-Year Change in IMT

	b	t	p
Spousal interactions	0.000	0.16	.87
DAS score	0.000	1.09	.27
DAS by spousal interactions	−0.000	−0.87	.38
Sex by spousal interactions	0.002	2.35	.02
Sex by DAS	0.001	0.78	.44
Sex by DAS by spousal interactions	0.0001	2.47	<.02

The sexes did not differ on social interaction frequency or marital adjustment (see Table 1). These two variables were correlated in the sample as a whole ($r = 0.27$, $p < .001$), and in men and women when examined separately (men: $r = 0.21$, $p < .05$; women $r = 0.33$, $p < .01$). Indices of the quality of spousal interactions (negative affect, conflict, agreeableness, intimacy) also were correlated with DAS scores in expected directions (data not shown).[2]

Table 2 displays results for the primary analyses. Contrary to expectations, neither spousal interaction frequency nor marital adjustment was associated with IMT change. The spousal interaction frequency by marital adjustment cross-product similarly was not significant. Thus, among the sample as a whole, neither how often subjects interacted with spouses, the adjustment level of their marriages, nor the interaction of those two factors predicted IMT progression.[3]

Also shown in Table 2, however, is a significant sex by spousal interaction frequency interaction that was qualified by a sex by spousal interaction by marital adjustment interaction. Decomposition of the complex interaction revealed a significant moderating effect of marital adjustment on the association between spousal interaction frequency and IMT change among men and a marginal moderating effect among women. To further explore this apparent moderating influence of marital adjustment, we examined the simple effect of spousal interaction frequency on IMT change at one SD above and below the respective male and female sample mean DAS scores (see Table 3). Among men with better marital adjustment, frequent spousal interaction was associated with decreased IMT change over the follow-up; among men with

[2]Interested readers are referred to Janicki et al. (in press) for further details.
[3]Separate analyses for each DAS subscale yielded similar results and are not reported here.

TABLE 3. Analysis of Simple Slopes for Sex by Spousal Interaction by Marital Quality Interaction

	Men (n = 131)			Women (119)		
	b	t	p	b	t	p
DAS by spousal Interactions	−0.0001	−2.29	.02	0.0001	1.71	.09
Spousal interactions						
High DAS	−0.003	−2.21	.03	0.003	2.94	.004
Low DAS	0.001	0.95	.34	−0.000	−0.01	.99

worse marital adjustment, spousal interaction frequency was unrelated to IMT change. By comparison, among women who reported better marital adjustment, more frequent spousal interaction was associated with increased IMT change during the follow-up. These results are displayed graphically in Figures 2 and 3.

The number of spousal interactions may reflect two factors: the intensity of marital engagement and more general factors related to the sociability of the subjects, as reflected in the frequency of social interaction (whether with the spouse or with others). We found that total social interaction frequency was an independent predictor of IMT change (b = 0.002, t = 2.61, p = .01). When analyses of spousal interactions were adjusted for total number of social interactions, the effect of spousal interaction frequency on IMT change among women failed to reach significance (b = 0.001, t = 1.33, p = .19). The proportion of social interactions that was spousal interactions was unrelated to IMT change (b = 0.07, t = 1.34, p = .18). Corresponding analyses among men showed that total social interactions were unrelated to IMT change (b = 0.00, t = 0.69, p = .49).

It is possible that a higher frequency of social interactions may be indicative of a larger social network. Though availability of a diverse social network is thought to buffer against potentially harmful effects of daily stress, multiple obligations within that network may place women under considerable demands. In other words, frequent social interactions among the women in the present sample might have been a marker for

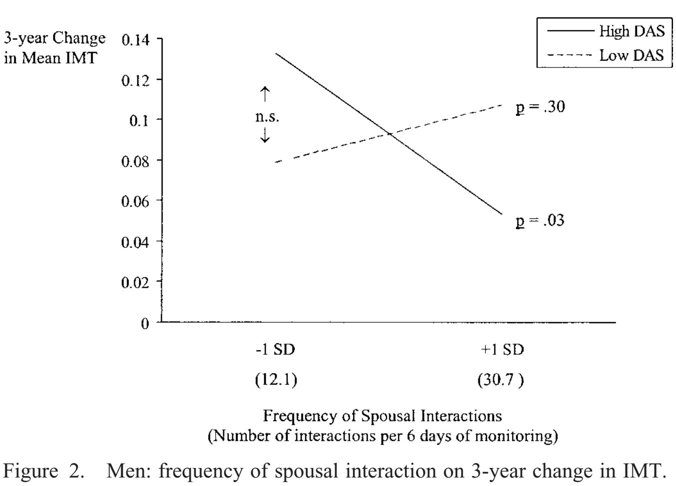

Figure 2. Men: frequency of spousal interaction on 3-year change in IMT. Interaction with DAS score.

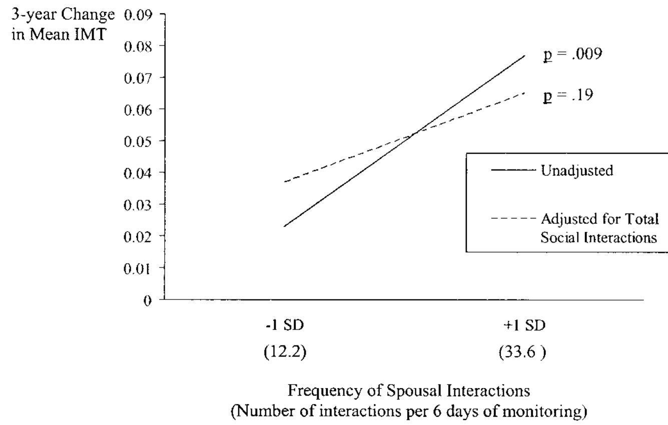

Figure 3. Women: frequency of spousal interaction on 3-year change in IMT. Interaction with DAS score.

the strain associated with role overload. To test this hypothesis, we examined in exploratory analyses whether participation in a diverse social network, as measured by the SNQ (23), explained the apparent CVD risk associated with frequent social interactions among women. Social network diversity was positively associated with total social interaction frequency among the entire sample (r = 0.16, p = .01) and among women specifically (r = 0.19, p = .03). However, network diversity was unrelated to IMT in women when included in the model with spousal interaction frequency and total social interaction frequency (b = 0.003, t = 0.51, p = .61). Network diversity was not significantly related to social interaction frequency when examined among men (r = 0.13, p = .13) and did not predict IMT change (b = −0.00, t = −0.26, p = .79).

In further exploratory analyses, we examined a number of potential biological (body mass index, ABP, clinic BP, cholesterol, and triglyceride levels[4]), behavioral (smoking and alcohol consumption, exercise), and psychosocial (quality of social interactions, affect and personality variables) mediators that might explain the observed associations between spousal interaction frequency and IMT change among men and women, respectively. First, we examined correlations between spousal interaction frequency and the potential mediators. More frequent spousal interactions among women were related to lower ambulatory DBP (r = −20, $p < .05$) and to lower average ratings of conflict during spousal interactions (r = −0.26, $p < .01$). There was a trend association between total social interactions and (a) change in total cholesterol (p = .07) and (b) use of cholesterol-lowering medication (p = .06) such that women who engaged in more frequent social interactions showed a greater increase in total cholesterol over the 3 years of follow-up and were less likely to have been prescribed cholesterol-lowering medication. More frequent social interactions among women also were associated with higher scores on Buss-Perry Aggression (r = 0.23, $p < .05$).

[4]Data on body mass index, cholesterol, triglycerides, and clinic BP were collected at baseline and follow-up. Changes in these variables across the two assessments (follow-up to baseline) were examined as mediators.

By comparison, more frequent spousal interactions among men were associated only with a reduction in clinic SBP during the 3 years of follow-up ($r = -0.22$, $p < .05$). Men's total social interactions were not related to any other potential psychosocial or biobehavioral mediators.

We next examined, in individual models, whether addition of any of the potential mediators reduced the strength of association between spousal interactions and IMT change. Although ambulatory SBP was independently associated with IMT change in women ($b = 0.002$, $t = 2.04$, $p < .05$), it failed to explain the association between frequent social interactions and IMT change. None of the remaining potential biobehavioral or psychosocial mediators were significantly associated with IMT change; inclusion of these mediators in the models failed to explain the change in IMT associated with spousal interactions among either sex.

DISCUSSION

We sought to elaborate on the extant research on marital quality and cardiovascular health. Specifically, we examined whether spousal interaction frequency is associated with 3-year progression of subclinical CVD, and whether the strength and direction of that association depends on level of marital adjustment. Our findings suggest the following: (1) spousal interaction frequency is associated with different outcomes among men and women; (2) the effect of frequent spousal interaction among men is moderated by marital adjustment such that, among men in better-adjusted marriages, frequent spousal interaction was associated with less IMT progression; and (3) there appears to be a trend for more frequent total social interactions to predict greater IMT progression among women, especially among those with higher levels of marital adjustment.

The synergistic effect of spousal interaction frequency and marital adjustment on IMT progression among men was consistent with the ABP findings reported by Baker et al. (9): Persons in well-adjusted marriages who interact frequently with their spouses received the greatest apparent cardiovascular health benefit. In this way, the present findings contribute to the growing literature examining the importance of qualitative, as well as structural, features of social relationships to health. Further, the present findings elaborate on the literature on marital quality and health, specifically, by suggesting that, among men, daily spousal interactions may be the conduit through which health benefits associated with high marital quality may be conferred.

An unexpected finding of the present study was the trend for frequent spousal interaction to predict greater IMT change among women, especially among those with better marital adjustment (higher DAS scores). This counterintuitive association may be explained largely by the fact that women who reported more frequent spousal interactions also engaged in more frequent total social interactions. We explored the hypothesis that frequent social interactions may have been a marker for strain associated with multiple social role obligations. Though social interaction frequency was associated with having a diverse social network, social network score was unrelated to IMT change and, thus, did not explain the apparent detrimental effect of frequent social interactions on cardiovascular health among women. The general quality of women's social interactions (e.g., conflictual versus agreeable) similarly did not explain these outcomes. One potential explanation for this unexpected finding might involve unmitigated communion, or the tendency to become overinvolved in the care of others to the detriment of the self (28). It is possible that women in the present sample who report better marital adjustment are more likely to assume caregiving responsibilities for their spouse and family members and that, at some point, the carrying out of these responsibilities may become detrimental to women's own health. This pattern is suggested by the marginal inverse association between total social interaction frequency and use of cholesterol-lowering medication among women in the present sample. Future investigations might examine the association between unmitigated communion and progression of subclinical CVD in women.

The lack of a main effect for marital adjustment among the present sample stands in contrast to the findings reported by Gallo et al. (6), which indicated that better marital adjustment was associated with slowed IMT progression among women. A number of factors might contribute to this difference between studies. First of all, the present study employed the DAS to measure marital adjustment, whereas Gallo et al. (6) used a novel measure that was designed by the authors. It is possible that the instrument employed in the earlier study measured some feature of the marital relationship that is not captured by the DAS and that is associated with cardiovascular health. Another explanation may concern the timing of the marital adjustment measure relative to IMT assessment. Gallo et al. (6) assessed marital adjustment 11 years before initial IMT evaluation, whereas the present study assessed marital adjustment and baseline IMT contemporaneously. It is possible that marital quality during pre- or perimenopause, the life stage during which Gallo and colleagues (6) evaluated their participants, may be more important to the prediction of later CVD outcomes among women relative to marital adjustment during menopause or later. Finally, the earlier study (6) employed a sample that was much younger at enrollment than was the present sample (42 to 50 versus 50 to 70). Women's risk for CVD events lags behind that of men by approximately 10 to 15 years (29). In this way, it might be reasonable to assume that the CVD-free participants in the Gallo et al. (6) study were fairly representative of the larger population of middle-aged women. By comparison, the healthy, CVD-free participants in the present study may represent a somewhat "protected" group whose risk for CVD is unaffected by marital adjustment. The relative health of the present sample also might explain why we failed to detect a main effect association between poor marital adjustment and worse outcomes as has been reported by previous research (3). Orth-Gomer et al. (3) found higher levels of marital distress to predict an increased risk of recurrent MI among persons with preexisting CVD. Perhaps the detrimental impact of poor marital adjustment is realized at later stages of the disease process. More studies that examine subclinical CVD progression in healthy samples are needed to further address this issue.

Limitations

The findings of the present report should be interpreted within the context of a few methodologic limitations. First of all, the present study assessed marital adjustment only at baseline. Marital quality may wax and wane during the course of a relationship that spans several decades. Thus, it is possible that participants' reports of current marital quality were not representative of the average level of marital quality that had been experienced throughout the marriage. Our assessment of spousal interaction frequency, as well, was administered only at baseline. Assessment of marital quality and spousal interaction frequency or quality at multiple time points would have enabled us to determine if temporal declines in marital quality or changes in the frequency of communication with the spouse coincide with CVD progression.

Other limitations concern demographic characteristics of the present sample. The sample employed here was fairly homogeneous with respect to race/ethnicity (91.6% white). As the experience of marriage may differ among persons of differing racial and ethnic backgrounds (30), it is possible that the present findings would not generalize to other groups. Our sample was also somewhat more highly educated than the population at large. As highest level of educational attainment was used as a proxy measure for socioeconomic status, it may be inferred that our sample also was above average in terms of SES. Better access to economic resources as a function of being married has been associated with lower mortality rates among women (31). Potential health benefits associated with marital relationship variables may be more apparent in samples with lower SES, where economic resources do not compensate for possible detriments imposed by these factors. Finally, as previously noted, our sample was composed of healthy, older adults with no evidence of preexisting CVD at baseline. As CVD of any type is not uncommon among persons in this age range, it is possible that the older adults who comprised the present sample represent a comparatively protected group.

Despite the acknowledged limitations, the present study makes novel contributions to the existing research on psychosocial factors and CVD. This study is the first prospective investigation to apply a real-time data collection technique to examine the effects of daily spousal interactions on cardiovascular outcomes. Use of real-time assessment via EMA (11) allowed us to derive a measure of spousal interaction frequency from participants' reports of spousal interactions *as they took place* during daily life. The relative accuracy in assessment of spousal interaction frequency that is afforded by the present EMA method allows us to identify a behavioral component of the marriage experience that may have important implications for cardiovascular health.

Another contribution of the present study was the inclusion of a measure of subclinical CVD progression (IMT) as the outcome. Although Gallo et al. (6) measured IMT progression as a function of marital adjustment, no known prospective study to date has examined IMT change relative to frequency of spousal interaction. In this way, the present findings complement and extend those of Baker et al. (9) by suggesting, among men, a synergistic association between marital adjustment and spousal interaction frequency on a marker of subclinical disease that may be more strongly indicative of CVD progression.

Implications

The present findings have important implications for the future of marriage and health research. The finding that spousal interaction frequency was associated with IMT progression among men in well-adjusted but not poorly adjusted marriages suggests the following: (1) among men in the present sample, being in a poorly adjusted marriage does not elevate risk for poor health outcomes; and (2) being in a well-adjusted marriage appears to benefit men's cardiovascular health, but only when combined with frequent spousal interaction. This latter conclusion implies that exposure to the spouse via spousal interaction is necessary for the protective effect of good marital adjustment to be translated into health benefits. It is possible that, among men, frequent interaction with a satisfying marital partner may elicit physiologic changes that are themselves protective against development or progression of CVD. Alternatively, men who are satisfied with their marriages may be more likely to accept helpful advice from their wives. To the extent that women may be guiding their husbands' health behaviors during at least some spousal interactions, more frequent interaction within the context of a well-adjusted marriage may have the ultimate effect of improving married men's health behaviors. Future investigations might explore potential mediating mechanisms by examining whether happily married men who interact frequently with their spouses engage in more healthful behaviors or, alternatively, display differing physiologic profiles in terms of factors that might influence cardiovascular outcomes.

The counterintuitive finding that more frequent spousal and total social interactions among women in better-adjusted marriages predicted greater IMT progression suggests that the role of social relationships in women's health is complex and likely influenced by additional factors. Future investigations might explore whether the association between social interactions and women's health is moderated by personality factors such as unmitigated communion.

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