Close Relationships and Health in Daily Life: A Review and Empirical Data on Intimacy and Somatic Symptoms

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Objective: To review research on close relationships and health in daily life, with a focus on physiological functioning and somatic symptoms, and to present data on the within-person effects of physical intimacy on somatic symptoms in committed couples' daily life. The empirical study tested whether prior change in physical intimacy predicted subsequent change in symptoms, over and above their concurrent association. In addition, the study tested if increasing and decreasing intimacy had asymmetric effects on symptom change. **Methods:** In this study, 164 participants in 82 committed couples reported physical intimacy and somatic symptoms once a day for 33 days. **Results:** Prior within-person change in intimacy predicted a subsequent reduction in symptoms; when a person's intimacy increased from one day to the next day, then symptoms decreased over the following days ($B = -0.098$, standard error [SE] = 0.038, $p = .013$). This lagged effect of intimacy held over and above the association of concurrent change in intimacy and symptoms ($B = -0.122$, SE = 0.041, $p = .004$). The study found asymmetric effects of prior increase and decrease in intimacy; prior intimacy increase predicted reduced subsequent symptoms ($B = -0.189$, SE = 0.068, $p = .047$), whereas prior intimacy decrease was unrelated to subsequent symptoms ($B = -0.003$, SE = 0.063, not significant). There was no evidence for asymmetric effects of intimacy increase and decrease on concurrent symptom change. **Conclusions:** Close relationships exert influences on health in daily life, and part of this influence is due to intimacy. **Key words:** intimacy, somatic symptoms, close relationships.

INTRODUCTION

Close relationships are an integral part of daily life and central to well-being. Although the general importance of close relationships for health is widely accepted, the processes behind this link are only partly understood. Research in daily life (for reviews, see references (1–10)) can make important contributions to a better understanding of the processes linking close relationships and health. Research in daily life has the goal of capturing processes in daily life as close in time as possible, either with self-reports or with automatic assessments. Thereby, the resulting data depict the social and health processes over time, including how variable each individual is and how similar individuals are to others. The challenging flipside of the richness of this approach is that theories and data analysis need to reflect the multilevel structure of such data; this is particularly relevant for studying relationships in daily life. For example, in longitudinal dyadic designs, theories and data analysis need to address not only variability and correlations among the repeated measures of the individuals but also dependence between the members of the dyad (11,12). We first review studies of close relationships and health in daily life. Then, we present an example of how studies of daily process variables enrich the understanding of mechanisms involved. Specifically, we examine how changes in physical intimacy are related to changes in somatic symptom reports.

Effects of Close Relationships on Health in Daily Life

More than two decades ago, House and colleagues (13) argued that the effects of close relationships on health are comparable to risk factors such as cigarette smoking, elevated blood pressure and blood lipids, obesity, and physical inactivity. In the following years, a wealth of research confirmed their conclusion: A recent meta-analysis of 148 studies reported that deficits in close relationships increased the risk for mortality and that these effects are comparable to other well-established risk factors (14). To begin to identify the processes by which relationships affect health, Berkman and colleagues (15) suggested a conceptual framework model reaching from macro-level social-structural conditions to mezzo-level characteristics of social networks to micro-level psychosocial mechanisms and pathways. In their view, both the quantity of social ties and the quality of these relationships matter for health: The culturally and socio-economically embedded social networks provide opportunities for a wide range of psychosocial mechanisms, encompassing social support, social influence and norms, social engagement and companionship, person-to-person contact including physical intimacy, and access to resources and material goods. These psychosocial mechanisms affect health through three parallel and nonredundant pathways, that is, physiological, psychological, and health behavioral pathways.

Empirical evidence supports parts of this model, although much more work needs to be done. *Social network* characteristics such as the mere availability of social ties are related to health benefits (e.g., living with someone versus living alone (14)). However, the quality of a person's social interactions and how lonely someone feels seem to matter over and above mere social integration (16–18). Individuals in happy relationships show the most health benefits, whereas individuals who are unhappy in their close relationships are no better off than singles (19–22). Among specific *psychosocial mechanisms*, social support has been studied most frequently. Perceived and received support seems to influence health, with emerging evidence for the postulated *pathways* (23,24). Experiments with humans (25,26) and animals (27) underscore the evidence for a causal link between close relationships and physiological pathways. Positive social relationships might lead to better cardiovascular function, neuroendocrine function including glucocorticoids and oxytocin, immune function, and less inflammation (23,27,28).

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Table 1 reviews studies of close relationships and health in daily life, with a focus on physiological pathways and somatic symptoms, as these areas have not been reviewed despite the increasing number of relevant studies in daily life (for reviews of close relationships, health behaviors, and psychological well-being, see Mehl and Conner (9) and Cohen and Lemay (54)). Examining the day-to-day processes connecting close relationships and health is crucial to a better understanding of how these different levels might operate. We identified studies using the keywords ambulatory assessment, experience sampling, ecological momentary assessment, daily diaries, time sampling, event sampling, intensive longitudinal, and within-person variability in the databases PsychINFO and MEDLINE. Studies were included in the review if they examined close relationships (with the following keywords: social, social network, social support, couple, relationship, spouse, partner, family, coworker, peer, intimacy), had a physiological or symptom health outcome (with the following keywords: cardiovascular health, blood pressure, biochemical processes, neuroendocrine processes, cortisol, oxytocin, somatic or physical symptoms, sleep, pain), and followed participants for more than 1 day. Additional studies were identified from review articles and literature searches for primary authors.

Relationships and Physiological Processes

Relationships and Cardiovascular Health

There is strong evidence for a link between relationships and cardiovascular health in daily life (21,29,31,33–37), as has been found in laboratory and epidemiological studies (32,55–59). Social network characteristics matter in daily life (32,55). For example, individuals with larger social networks reported feeling less lonely, which, in turn, was associated with lower ambulatory blood pressure (32,55). In addition to network characteristics, specific social interactions and their quality seem to influence cardiovascular health on a daily level as well (for positive interactions, see references (21,31,33–35,37); for negative interactions, see references (21,29,30,36)). For example, individuals had lower blood pressure when they interacted with their partner rather than with other persons or when alone (21,31,34), and an intervention that increased physical intimacy lowered husbands' blood pressure (33). In sum, the available evidence indicates that both the quantity and quality of close relationships influence cardiovascular health in daily life, supporting Berkman and colleagues' framework model (15).

Relationships and Neuroendocrine Processes

Some studies looking at the link between relationships and neuroendocrine processes in daily life have addressed social network characteristics (41,43), whereas most focused on relationship quality (33,38–46). In studies of social network characteristics, divorce (versus being in a happy marriage) and loneliness were associated with cortisol and testosterone levels (41,43). In addition to social integration, the quality of the available social interactions influenced neuroendocrine processes on the daily level. On days with more positive interactions in committed couples, such as higher physical partner intimacy (33,40), relationship satisfaction (44), and support (46), individuals showed lower cortisol levels than on days with fewer positive interactions (39). Close relationships can also lead to negative effects and spillover of distress from one partner to the other. Both a person's own activities and his or her partner's activities were related to daily cortisol levels (38,42,44,45). As for cardiovascular health, the reviewed studies support that both the quantity and the quality of close relationships influence neuroendocrine processes, as predicted (15).

Relationships and Somatic Symptoms

A more limited number of studies have used lists of somatic symptoms, sleep quality, and pain as outcomes of interest and focus mostly on relationship quality as predictor. Two studies examined the link between relationships and lists of somatic symptoms; they found that women—but not men—with higher interaction quality and higher relationship quality reported fewer somatic symptoms (47). Two studies specifically addressed sleep quality (49,50). Lonely individuals had poorer quality of sleep (49). Among cosleeping couples, positive spousal interactions predicted better sleep quality (50). Three studies explored the link between relationships and pain in patients with long-term disease (51–53). Support seeking reduced pain in patients with osteoarthritis but increased pain in patients with rheumatoid arthritis (51). The quality of pain-related partner interactions seems to be central to pain reduction (52) and can be trained: An intervention study where both patient and partner learned pain coping skills reduced pain in patients with osteoarthritis (53). In sum, for somatic symptoms, most of the available studies addressed relationship quality. The bulk of the effects support the hypothesized link that positive relationship interactions predict fewer somatic symptoms, better sleep, and less pain, as hypothesized (15).

Conclusions

This narrative review finds that close relationships indeed influence health in daily life, as suggested by the framework model (15). Both the quantity and the quality of social interactions predict daily changes in physiological function and a number of somatic symptoms including pain and sleep. Close relationships "get under the skin" on a daily basis and might influence long-term health outcomes cumulatively. The review underscores the positive and protective effects of close relationships on health. However, close relationships can also have negative effects, especially when they are contentious (29,30, 36,37,51). Such negative or mixed effects come as no surprise to researchers familiar with the mixed effects of received social support on distress (60–62). Future studies will be needed to disentangle positive and negative effects of social relationships on health and to differentiate the specific contributions and interrelations of different psychosocial mechanisms.

Research in daily life has three main advantages in advancing our understanding of relationships and health: First, research in daily life has *ecological validity*, as is evident from

TABLE 1. Overview of Research on Close Relationships and Health in Daily Life

Authors and Sample[a]	Relationship Predictor, Outcome, Results
	Cardiovascular health
Fuligni et al. (29): 69 adolescents; M age = 17.78 y	A greater frequency of daily interpersonal stress was associated with higher levels of C-reactive protein (an inflammatory indicator of cardiovascular risk).
Gallo and Matthews (30): 205 high school students; age range = 14–16 y	During social interactions, individuals lower in anxious attachment showed lower ambulatory blood pressure; more avoidant adolescents exhibited increased blood pressure in response to social conflict.
Gump et al. (31): 120 healthy adults; M age = 35 y; age range = 23–50 y; married or living together for at least 3 mo	Social interaction with one's partner was associated with reduced ambulatory blood pressure compared to social interactions with other individuals.
Hawkley et al. (32): 135 undergraduate students; M age = 19.2 y	Individuals with larger social networks had lower ambulatory blood pressure.
Holt-Lunstad et al. (21): 204 married and 99 single males and females (*n* = 303); age range = 20–68 y	Married individuals had greater blood pressure dipping than single individuals. High marital quality was associated with lower ambulatory blood pressure. Single individuals had lower ambulatory blood pressure than those in low-quality marriages.
Holt-Lunstad et al. (33): 34 healthy married couples (*n* = 68); M age = 25.2 y; age range = 20–39 y	Participants in a ''Couple Contact Enhancement'' intervention group had lower 24-h systolic blood pressure at the posttreatment follow-up than controls.
Holt-Lunstad et al. (34): 102 healthy normotensive men (*n* = 49) and women (*n* = 53); M age = 24 y; age range = 18–46 y	Interactions with family members and spouses were associated with lower ambulatory blood pressure.
Janicki et al. (35): 250 healthy, older adults; 48% female; M age = 61 y	Among men with better marital adjustment, more frequent spousal interaction was associated with fewer intima-media thickening progression; social interaction frequency predicted greater intima-media thickening progression among women.
Kamarck et al. (36): 340 older adults from the Pittsburgh Healthy Heart Project; 51% female; age range = 50–70 y	Healthy adults had lower blood pressure during low-conflict interactions than during high-conflict interactions.
Vella et al. (37): 341 healthy adults (168 men and 173 women; M age = 60 y) from the Pittsburgh Healthy Heart Project	During emotionally intimate interactions, individuals with high hostility showed lower blood pressure when intimacy was high. During instrumental support, individuals with low hostility showed lower blood pressure when support was high; individuals with high hostility showed the reverse pattern.
	Neuroendocrine processes
Adam et al. (38): 156 older adults; 48% female; M age = 57 y; range = 50–68 y; 58% married	Higher average on feeling lonely/sad/overwhelmed was associated with higher cortisol awakening response; feeling more lonely/sad/overwhelmed than usual the day before was associated with higher cortisol awakening response the next day.
Adam and Gunnar (39): 70 mothers of toddlers; M age = 34 y	Positive relationship functioning was associated with higher morning cortisol levels and a steeper decline in cortisol throughout the day.
Ditzen et al. (40): 51 German dual-earner couples; M age = 37 y	Intimacy in everyday life was associated with reduced salivary cortisol secretion.
Doane and Adam (41): 108 participants (27 were male); M age = 19 y	High levels of trait or long-term loneliness resulted in flatter cortisol slopes across the day, increased cortisol awakening responses, and momentary increases in cortisol.
Holt-Lunstad et al. (33): 34 healthy married couples (*n* = 68); M age = 25.2 y; range = 20–39 y	Participants in a ''Couple Contact Enhancement'' intervention group had greater decreases in α-amylase and increases in salivary oxytocin at the posttreatment follow-up than controls.
Klumb et al. (42): 52 German dual-earner couples with at least one child younger than 5 y; M age = 37 y	For every additional hour of work, a person or his or her partner performed, the person's total cortisol concentration increased, and with every hour of housework the partner performed, it decreased.
Powell et al. (43): 40 premenopausal women, 20 undergoing divorce or separation, 20 happily married controls matched for age, ethnicity, and education; M age = 45.7 y; range = 42–52 y	Women undergoing divorce or separation had higher evening cortisol on both days, showed less suppression of salivary cortisol in response to low-dose dexamethasone, and higher testosterone than happily married matched controls.

TABLE 1. *(Continued)*

Authors and Sample[a]	Relationship Predictor, Outcome, Results
Saxbe et al. (44): 30 couples (*n* = 60); age range = 28–58 y; median = 41 y	Wives with higher marital satisfaction showed a more pronounced daily cortisol pattern with higher morning increase and stronger decrease during the rest of the day than wives with lower marital satisfaction. Husbands' marital satisfaction was unrelated to daily cortisol pattern. Negative social interactions in the afternoon at work predicted higher evening cortisol in husbands but not wives.
Slatcher et al. (45): 37 couples; M age = 35.6 y for husbands, M age = 34.5 y for wives	Wives' cortisol levels showed a positive correlation with their own work worries and with their husbands' work worries. Husbands' cortisol levels showed a positive correlation only with their own work worries. Wives high in marital satisfaction and/or in marital disclosure showed a weaker correlation between work worries and cortisol than wives low in both marital satisfaction and disclosure.
Turner-Cobb et al. (46): 130 women with metastatic breast cancer; M age = 53.2 y	A greater quality of social support was associated with lower cortisol concentrations.
Somatic symptoms	
Reis et al. (47): 43 male and 53 female undergraduates	Women—but not men—who reported higher-quality and more meaningful social interactions, less loneliness, and less fear of negative evaluation also reported fewer daily somatic symptoms.
Yorgason et al. (48): 96 dyads (*n* = 192); M age = 71 y (women) and 77 y (men)	Wives—but not husbands—with higher marital satisfaction reported fewer daily symptoms.
Sleep	
Cacioppo et al. (49): 64 undergraduates (participants were grouped according to their loneliness Scale; lonely ≥46, middling 33 < total score < 39, nonlonely <28)	Lonely individuals had poorer sleep efficiency and more time awake after sleep onset than nonlonely individuals in both controlled laboratory and home settings.
Hasler and Troxel (50): 29 heterosexual cosleeping couples (*n* = 58); age = 18–45 y; cohabitating for <6 mo or >10 y	Women slept better on nights when they perceived less negative interactions with their partner during the day; men slept better on nights when their female partners noted increased positive interactions that day.
Pain	
Affleck et al. (51): 71 (57.7% women) patients with osteoarthritis (M age = 62.11 y) and 76 (76.3% women) with rheumatoid arthritis (M age = 63.46 y)	Patients with osteoarthritis who sought emotional support one day experienced less pain the following day, whereas patients with rheumatoid arthritis indicated an increase in pain when they sought support the previous day.
Holtzman and DeLongis (52): 69 married individuals with rheumatoid arthritis, 84% female	Among patients with rheumatoid arthritis, day-to-day satisfaction with spouse responses to pain reduced catastrophizing, protected against its detrimental effects, and reduced the likelihood of feeling overwhelmed and helpless when dealing with daily pain.
Keefe et al. (53): 88 (34 men and 54 women) patients with osteoarthritis with persistent knee pain; M age = 62.6 y	In this intervention study, patients with osteoarthritis reported lower levels of pain, psychological disability, and pain behavior and reported higher scores on measures of coping attempts, marital adjustment, and self-efficacy when both partners completed the training for spouse-assisted pain coping skills, compared to participation in the control groups.

M = mean.
[a] The sample age mean and range are reported where available.
Numbers in parenthesis are references, unless otherwise indicates.

the reviewed studies. Researchers can be more confident that their findings will generalize when studying daily life than when conducting laboratory studies where they still need to demonstrate that the findings in the laboratory would occur in the real world as well. Second, research in daily life allows researchers to isolate *within-person change*. Because the same person with their specific situational and personal characteristics shows change, researchers can differentiate the influence of relatively stable characteristics (e.g., personality, sex, age, socioeconomic status) from time-varying processes (e.g., daily change in relationship interactions and health). Third, research in daily life allows a better understanding of *temporal order*, that is, which time-varying qualities of close relationships are especially relevant for changes in health outcomes and which comes first, change in relationships or change in health. Not all of the reviewed studies took full advantage of analyzing within-person change and temporal order. Therefore, we provide new data in the next section that illustrate the potential of research in daily life for understanding within-person change and temporal order.

EMPIRICAL STUDY OF INTIMACY AND SOMATIC SYMPTOMS IN DAILY LIFE

Physical intimacy is one understudied psychosocial mechanism for the effects of relationships on health (63–66) and has the potential to help gain a better understanding of the underlying physiological pathways. In prospective studies, physical intimacy predicted enhanced life expectancy (67–69). Physical intimacy and symptoms show considerable fluctuation across days (48,70,71). In this empirical study, we will focus on within-person fluctuation. We can view the fluctuations as daily within-person quasi-experiments that allow us to study the association between changes in intimacy and symptoms within the same person. We will review evidence that higher physical intimacy could lead to reduced symptoms on the same day but also on the next day.

The reasons for effects of intimacy on health are not well understood: Physical intimacy is an important predictor of relationship satisfaction and stability (72) and could therefore have broad effects on the stability of an individual's social network, psychosocial mechanisms, and physiological, psychological, and health behavioral pathways (15). A recent review summarized the pathways between intimacy and well-being (73). Physical intimacy and touch lead to decreases in heart rate, blood pressure, cortisol, and substance P; increases in oxytocin and serotonin; and enhanced immune function and gastrointestinal motility. These physiological changes co-occur with more relaxation and deep sleep, lower arousal and depression, and higher stress resistance and pain tolerance. Among the physiological, psychological, and health behavioral pathways, neuroendocrine processes could play a key role for linking intimacy and health. Oxytocin, a hormone released during physical intimacy (from warm touch to sexual arousal and intercourse (65,74–76)), is related to lower stress reactivity including activity of the hypothalamic-pituitary-adrenal axis and autonomic nervous system, lower pain sensitivity, faster wound healing, and more relaxation (21,40,65,66,77–80), speaking for an effect of physical intimacy on a wide range of somatic symptoms.

Thus far, there are few observational and intervention studies of physical intimacy in daily life. One study found that prior dyadic physical intimacy improved mood and reduced stress in women in daily life, but this study did not include physical health outcomes (70). Another study found a within-person association of physical intimacy and cortisol levels across 6 days: Participants had lower cortisol levels on days with higher intimacy (26). In an intervention study, pregnant depressed women whose partner provided massage therapy from the second trimester on reported reduced leg and back pain in comparison to a no-treatment control group (81). Another recent intervention study tested a "warm touch" intervention to increase couples' physical intimacy. Participants in the intervention group had lower α-amylase and higher salivary oxytocin than in the control group (33). The few existing studies indicate that intimacy might lead to reduced somatic symptoms within person in daily life.

The timing of intimacy effects on symptoms is not fully clear. Intimacy could have fast-acting effects on symptoms that last for several hours, leading to a same-day association between intimacy and symptoms. Such same-day associations would not rule out that there is bidirectional causation with higher intimacy leading to lower symptoms but also more symptoms leading to lower intimacy. Therefore, effects of intimacy on symptoms that last longer than 24 hours are particularly interesting. Experimental studies provide evidence that physical intimacy can have lasting effects on somatic symptoms. Positive touch and sexual arousal showed immediate and lasting pain-relieving effects (73,74,82,83) and induced muscle relaxation for several hours (84). In addition, physical intimacy and touch promoted better sleep (73,85), thus increasing restorative function with positive effects for health (86). If intimacy on one day leads to more relaxation and better sleep that night, possibly paralleled by better mood and longer-lasting physiological effects, intimacy effects on symptoms could extend to the next day. Such lagged within-person effects would help to establish temporal order between changes in intimacy and symptoms.

Finally, it is not clear if the effects of intimacy increase and decrease are symmetric. Gains and losses, for example, show asymmetric effects on risk taking (87). If we assume that high physical intimacy is the "active ingredient" that triggers a favorable physiological pattern, relaxation, and better sleep, intimacy increase should predict reduced symptoms on the same day and the next day. However, will days with lower-than-usual or no intimacy show increased symptoms on the same day and the next day? We expect that lower-than-usual intimacy could be indistinguishable from moderate intimacy. On days when intimacy is just average or lower-than-usual, the limited physical contact might not activate physiological and psychological pathways enough to influence symptoms, particularly on the next day.

In line with the evidence reviewed, the current study tested whether physical intimacy would lead to subsequent decrease in somatic symptoms within persons in everyday life, using daily evening reports of physical intimacy and somatic symptoms of both partners in committed couples. Couples usually spend time together in the evening (88) when physical intimacy is most likely to occur, and therefore, a reduction in symptoms should then be detectable the next day. Therefore, the current study tested a 1-day lagged effect of physical intimacy on somatic symptoms. The study tested the following hypotheses: a) Prior within-person change of intimacy will lead to subsequent improvements in symptoms, that is, when intimacy increases from one day to the next day, then symptoms will decrease in the following days. b) The prediction that prior within-person change in intimacy will predict subsequent change in somatic symptoms holds *over and above* the association of concurrent change in intimacy and symptoms, that is, when intimacy increases from one day to the next day, symptoms decrease in the same period. c) The study also explored asymmetric effects of prior and concurrent intimacy change on symptom change to see if increasing intimacy has a stronger effect on symptom change than decreasing intimacy. A stronger effect of increasing intimacy than decreasing intimacy would strengthen the causal claim that it is actually increasing intimacy that has effects on symptoms, not a lack of intimacy.

METHODS

Design and Participants

This study was part of a larger project investigating social support and stress and had a prospective longitudinal design with daily assessments during 35 consecutive days. After approval by the local institutional review board, couples were recruited through fliers and Internet postings. Eligibility criteria were that both partners were native English speakers, older than 18 years, in a committed heterosexual relationship, had been cohabiting for at least 6 months at the beginning of the study, had high-speed Internet access, a working e-mail address, and were sure that they would be able to fill out the daily online diary for the following 35 days. After initial contact, both partners were screened through telephone interviews for these criteria. All interested couples fulfilled eligibility criteria, except for two homosexual couples who were not included in this study. To ensure high retention, participants were paid up to $145 per person, including a $35 bonus for completing at least five morning and five evening entries per week. Both partners in each couple received a separate daily e-mail reminder to fill out an online diary every evening within 1 hour of going to bed. Participants were asked to complete the diary entries separately and not to share or discuss their answers with their partner. In addition, a research assistant checked participant data weekly and sent e-mail reminders to participants who missed entries. Initially, data were collected from 172 participants in 86 heterosexual couples who lived in the New York metropolitan area between June 2006 and February 2009. Data from four couples were excluded from this study because one or both partners filled out fewer than seven diary entries. The remaining 164 participants from 82 couples who both completed at least seven diary entries were included in this study; they filled out a total of 4736 diary days (on average, 28.88 days of the 5-week diary; range = 9–35 diary days). Participants (mean = 30.91 years, standard deviation [SD] = 9. 33; 43% were married) were, on average, very happy with their relationship (happiness in the Dyadic Adjustment Scale: M [SD] = 5.10 [1.27], range = 1–7). They had been romantically involved with each other for 6.41 years (SD = 7.30) and living together for 5.02 years (SD = 6.94). Most participants (77%) were employed. The ethnic makeup of the sample was diverse (55% were white/Caucasian, 14% were Hispanic, 17% were African-American, 12% were Asian, and 2% were from other ethnicities).

Measures

Somatic Symptoms

Somatic symptoms were measured with a shortened version of the symptoms checklist of Larsen and Kasimatis (89). Insomnia was added to the list. Each evening, participants were presented with a list of "troublesome things" to report if they had experienced any of them in the past 24 hours. The list contained the following six somatic symptoms: back/muscle ache, headache, insomnia, upset stomach, rash/skin irritation, and sick/injured. The symptoms variable indicates the number of symptoms a participant reported per day, ranging from 0 (no symptom checked) to 6 (all six symptoms checked). Participants in this sample reported, on average, half a symptom per day (between-person M [SD] = 0.47 [0.50], range = 0.00–3.33). Back/muscle aches were the most frequent symptom (average frequency per 30 days: back/muscle ache = 3.58, headache = 3.13, sick or injured = 2.58, upset stomach = 2.51, insomnia = 1.12, rash/skin irritation = 1.06). The variance decomposition for symptoms was 0.63, 0.20, and 0.43 for total, between-person, and within-person variances, respectively. The corresponding SDs were 0.79, 0.45, and 0.65. Our analytic model focused on day-to-day change in symptom count, ranging from −5.00 to 4.00. The within-person source of variation accounted for two thirds of the total variability in daily symptoms; as evidenced by the intraclass correlation (ρ_{ICC} = 0.32), a third of the total variability in symptoms was due to stable between-person differences.

Intimacy

Intimacy was measured with a continuous unipolar item. Each evening, participants indicated how much physical intimacy they experienced with their partner with the item: "Please use the following rating scale to characterize your relationship in the last 24 hours" on a 5-point rating scale. The end points of the rating scale were labeled as 1 "not physically intimate" and 5 "physically intimate"; we rescaled the daily report to have a range of 0 to 1 with 0.25 increments in between. Participants reported average daily intimacy just below the midpoint of the scale (between-person M [SD] = 0.39 [0.20], range = 0.00–1.00). The variance decomposition for intimacy was 0.10, 0.04, and 0.06, for total, between-person, and within-person variances, respectively. The corresponding SDs were 0.32, 0.20, and 0.25. As with somatic symptoms, our analytic model focused on day-to-day change in intimacy, ranging from −1.00 to 1.00. Within-person sources of variation accounted for nearly two thirds of the total variability in intimacy. The intraclass correlation (ρ_{ICC} = 0.38) indicated that slightly more than a third of the variation was attributable to stable between-person differences.

Data Analysis

Because we are interested in possible causal effects of changes in daily intimacy on symptom reports, we focused on the relation of daily changes in intimacy level to changes in symptom level. This approach eliminates the impact of between-person differences in overall level (90). Each time-varying construct can be decomposed into a stable person mean (the between-person part) and the time-varying fluctuation around the person's mean (the within-person part). For example, the outcome in this study, symptoms of individual i at time t, SYM_{it}, can be decomposed in a between-person part, SYM_B_i, indicating individual i's traitlike tendency to report more or fewer symptoms than other participants, and the within-person part, SYM_W_{it}, indicating how much more or fewer symptoms individual i reports on day t than his or her mean level. When the change score is computed, the trait effect is "differenced out," that is, the change score removes all between-person variance from the analysis and allows the analysis of change within person, as Equation 1 shows for change in symptoms.

$$\begin{aligned} SYM_{it} - SYM_{it-1} &= (SYM\_W_{it} + SYM\_B_i) - (SYM\_W_{it-1} + SYM\_B_i) \\ &= SYM\_W_{it} - SYM\_W_{it-1} \end{aligned} \quad (1)$$

Change in somatic symptoms from yesterday to today ($SYM_{it} - SYM_{it-1}$) can be interpreted as a within-person change. The ability to study within-person change is one of the main advantages of using a longitudinal design. We used general linear models in a multilevel context, but it was not necessary to estimate a random effect for the intercept because differencing eliminated the trait effect.

We hypothesize that changes in the level of intimacy will have both lagged and immediate effects on changes in somatic symptoms. For example, if intimacy is increased today relative to yesterday, then we predict that somatic symptoms will be reduced tomorrow relative to today, a lagged effect. We also predict that symptoms today will be reduced relative to yesterday, a concurrent effect. Because the lagged difference scores can only be computed for Day 3 and later, the first two diary days were excluded from the analyses, leaving up to 33 diary days for analysis. To model systematic effects of time, we created a variable for time, $DAYc18_{it}$, to represent the whole diary period of 33 days. It was centered at Diary Day 18, and thus, the intercept is interpreted as the expected symptom change on Day 18 for a person with no change in intimacy from Day 17 to 18. The models assume that missing data are missing at random, which means that, conditional on the predictor variables, the expected values of the missing observations are the same as the nonmissing observations.

Preliminary Analyses

To explore sources of dependence in change in somatic symptoms, initial double-intercept models were fit to the data (11,12,91). Residual covariance between male and female partners was very small (r = 0.08), indicating that changes in symptoms were rather independent between partners. Male and female participants' residual variances were very similar (0.66 and 0.67). Therefore, we moved in subsequent analyses to simpler models that assume similar residual variances between male and female partners and model both partners in each couple individually.

Model A: Prior Change in Intimacy as a Predictor of Symptom Change

To test the hypothesis that prior change in intimacy predicts subsequent change in somatic symptoms, the model shown in Equation 2 was fit to the data:

$$(\mathrm{SYM}_{it} - \mathrm{SYM}_{it-1}) = \gamma_{00} + \gamma_{01}\mathrm{DAYc18}_{it} + \gamma_{02}(\mathrm{INT}_{it-1} - \mathrm{INT}_{it-2}) + \varepsilon_{it} \quad (2)$$

Change in somatic symptoms from yesterday to today (SYM_{it} − SYM_{it-1}, symptoms of individual i for time t minus time $t-1$) was predicted by the grand mean γ_{00} of symptom change in this sample, the effect of diary day γ_{01} ($\mathrm{DAYc18}_{it}$, diary day for individual i at time t), and the effect γ_{02} of prior change in physical intimacy from 2 days ago to yesterday ($\mathrm{INT}_{it-1} - \mathrm{INT}_{it-2}$, intimacy of individual i for time $t-1$ minus time $t-2$).

Model B: Prior and Concurrent Change in Intimacy as a Predictor of Symptom Change

To test the hypothesis that prior change in intimacy predicts subsequent change in somatic symptoms, over and above the association of concurrent change in intimacy and symptoms, the model shown in Equation 3 was fit to the data:

$$\begin{aligned}(\mathrm{SYM}_{it} - \mathrm{SYM}_{it-1}) = \gamma_{00} + \gamma_{01}\mathrm{DAYc18}_{it} + \gamma_{02}(\mathrm{INT}_{it-1} - \mathrm{INT}_{it-2}) \\ + \gamma_{03}(\mathrm{INT}_{it} - \mathrm{INT}_{it-1}) + \varepsilon_{it} \quad (3)\end{aligned}$$

For this analysis, the effect γ_{03} of concurrent change in physical intimacy from yesterday to today ($\mathrm{INT}_{it} - \mathrm{INT}_{it-1}$, intimacy for individual i for time t minus time $t-1$) was added to Model A.

Model C: Differential Effects of Prior and Concurrent Increase and Decrease in Intimacy on Symptom Change

The first two models assumed that the effects of intimacy decrease and increase are symmetric, that is, that the effect of a 1-unit decrease in intimacy on symptom change is exactly the same as that of a 1-unit increase in intimacy in absolute numbers. Model C relaxed that assumption by incorporating information about the direction of intimacy change on each day. If prior intimacy increased ($\mathrm{INT}_{it-1} - \mathrm{INT}_{it-2} > 0$), the indicator variable $\mathrm{UP}_{i(t-1)-(t-2)}$ was set to 1; otherwise, it was set to 0. Similarly, $\mathrm{UP}_{it-(t-1)}$ was equal to 1 for concurrent increase in intimacy and 0 for no change or decrease. These indicators are included in the interaction terms in Equation 4:

$$\begin{aligned}(\mathrm{SYM}_{it} - \mathrm{SYM}_{it-1}) = \gamma_{00} &+ \gamma_{01}\mathrm{DAYc18}_{it} + \gamma_{02}(\mathrm{INT}_{it} - \mathrm{INT}_{it-2}) \\ &+ \gamma_{03}(\mathrm{INT}_{it} - \mathrm{INT}_{it-1}) \\ &+ \gamma_{04}(\mathrm{INT}_{it-1} - \mathrm{INT}_{it-2}) \times \mathrm{UP}_{i(t-1)-(t-2)} \\ &+ \gamma_{05}(\mathrm{INT}_{it} - \mathrm{INT}_{it-1}) \times \mathrm{UP}_{it-(t-1)} + \varepsilon_{it} \quad (4)\end{aligned}$$

With these interactions included, γ_{02} and γ_{03} represent the effects of decreasing intimacy, whereas γ_{04} and γ_{05} represent the difference in the effect size between increasing and decreasing intimacy. Significant effects for these interactions indicate that the slope for increasing intimacy is different in the −1 to 0 part and 0 to 1 part of the intimacy change dimension.

All three models have residual terms, ε_{it}, which indicate that portion of the symptom change score that is not explained by the respective model. Because the change scores depend on temporally adjacent reports of somatic symptoms, the residuals for days t and (t − 1) will be correlated, and this needs to be taken into account in the analysis (90). In SAS PROC MIXED, these residual correlations can be fit by specifying a Toeplitz pattern (see Appendix B, Supplemental Digital Content, http://links.lww.com/PSYMED/A41). All analyses were carried out using the MIXED procedure in SAS (version 9.2; SAS Institute, Cary, NC) with a significance level of .05 and nonsignificant findings were labeled as such. The Supplemental Digital Content file explains the analyses in more detail: Appendix A gives a detailed description of the analysis in Model C, Appendix B explains the Toeplitz error variance covariance structure, and Appendix C shows the syntax in SAS 9.2 and the structure of the data set.

RESULTS

Change in Intimacy as a Predictor of Change in Somatic Symptoms

Model A: Prior Change in Intimacy as a Predictor of Subsequent Symptom Change

Results from Model A supported the hypothesis that prior change in intimacy predicts subsequent change in somatic symptoms. As shown in Table 2 (see γ_{02} in the first column of results), a unit increase in prior intimacy was associated with a decrease of symptoms of −0.098, t = −2.55, df = 161, p < .013. A unit change in intimacy represents a change from the highest level to the lowest level or vice versa. The size of this effect becomes more interpretable if we remember that a typical participant reported, on average, half a symptom per day (0.47), that is, one symptom every 2 days. A typical participant's symptom load decreased between yesterday and today from half a symptom to a third of a symptom the next day when prior intimacy increased by one unit (from "Not Physically Intimate" to "Physically Intimate") in the two previous days, that is, the symptom load was reduced by −0.098 units from 0.47 symptoms yesterday to 0.37 today. The expected change in somatic symptoms on Diary Day 18 for persons with no intimacy change was significant but small (fixed intercept γ_{00} = −0.008); symptom change showed a nonsignificant increase over the diary period (fixed slope of time γ_{01} = 0.022). Residuals for adjacent days were correlated −0.48; the residual variance (ε_{it}) for Model A was 0.69.

Model B: Prior and Concurrent Change in Intimacy as Predictors of Symptom Change

Results from Model B (Table 2, second column of results) supported the hypothesis that prior change in intimacy predicts subsequent change in somatic symptoms, over and above the concurrent association of change in intimacy and symptoms. The estimate of γ_{02} was virtually unchanged from Model A after adjusting for concurrent intimacy change, γ_{02} = −0.098, t = −2.58, df = 160, p < .011. Concurrent change itself had a significant association with symptom change, indicating that, with a unit increase in intimacy, there was a decrease in symptoms, γ_{03} = −0.122, t = −2.96, df = 160, p < .004. This effect indicates that, for a typical participant, a 1-unit increase in intimacy from yesterday to today was associated with a decrease of the usual symptom load of half a symptom yesterday to a third of a symptom today, that is, the typical symptom load was reduced by −0.122 units from 0.47 symptoms yesterday

TABLE 2. Estimates of Multilevel Models: Change in Symptoms From Yesterday to Today Predicted By Prior and Concurrent Change in Intimacy

			Model A: Prior Change		Model B: Prior and Concurrent Change		Model C: Differential Effects of Prior and Concurrent Increase and Decrease	
Fixed effects, γ (SE)								
Intercept for Day 18		γ_{00}	−0.008	(0.004)[a]	−0.008	(0.004)[a]	−0.001	(0.008)
Day, centered at Day 18	$DAYc18_{it}$	γ_{01}	0.022	(0.015)	0.022	(0.015)	0.020	(0.016)
Prior change in intimacy	$INT_{it-1} - INT_{it-2}$	γ_{02}	−0.098	(0.038)[a]	−0.098	(0.038)[a]	−0.003	(0.063)
Concurrent change in intimacy	$INT_{it} - INT_{it-1}$	γ_{03}			−0.122	(0.041)[a]	−0.189	(0.068)[a]
Prior increase in intimacy	$(INT_{it-1} - INT_{it-2}) \times UP_{i(t-1)-(t-2)}$	γ_{04}					−0.192	(0.096)[a]
Concurrent increase in intimacy	$(INT_{it} - INT_{it-1}) \times UP_{it-(t-1)}$	γ_{05}					0.117	(0.089)
Random effects, estimate (SE)								
Autocorrelation	Toeplitz	ρ	−0.48	(0.010)[a]	−0.48	(0.010)[a]	−0.48	(0.010)[a]
Residual		ε_{it}	0.69	(0.018)[a]	0.69	(0.018)[a]	0.69	(0.018)[a]

[a] $p < .05$. $n = 164$.

to 0.35 today. The intercept and patterns of residual correlations for Model B were similar to the results for Model A.

Model C: Differential Effects of Prior Increase and Decrease in Intimacy on Symptom Change

Analyses of Model C (Table 2, third column of results) suggested that the effect of prior change in intimacy was not symmetric. A prior decrease in intimacy was not significantly related to subsequent symptom change (fixed slope of prior intimacy decrease $\gamma_{02} = -0.003$, $t = -0.05$, $df = 158$, not significant), indicating that prior intimacy decrease did not predict a change in a typical participant's average symptom load of 0.47 symptoms between yesterday and today. A prior increase in intimacy was more related to symptom reduction than intimacy decrease, as the significant interaction term γ_{04} shows, $\gamma_{04} = -0.192$, $t = -2.00$, $df = 158$, $p < .047$. A 1-unit increase in prior intimacy predicted a reduction in a typical participant's symptom load from half a symptom today to a quarter of a symptom, that is, the typical symptom load was reduced by −0.192 units from 0.47 yesterday to 0.28 symptoms today, resulting in a 41% decrease in usual symptom burden.

The analogous interaction term for concurrent intimacy change was not significant, $\gamma_{05} = 0.117$, $t = 1.31$, $df = 158$, not significant, indicating that the effect of increasing intimacy did not differ from the effect of decreasing intimacy, $\gamma_{03} = -0.192$, $t = -2.00$, $df = 158$, $p < .047$, that is, decreasing and increasing concurrent intimacy had symmetric effects, as Model B had shown. Figure 1 is a graphical representation of the parameter estimates in Table 2. The benefits of lagged change for symptom reduction were only apparent for days when intimacy increased. For concurrent intimacy change, the benefits of intimacy change were apparent for both decreasing and increasing intimacy.

Reversing the Order of Prediction: Change in Symptoms as a Predictor of Change in Intimacy

Analyses of symptom change predicting intimacy change did not yield evidence that prior change in symptoms leads to subsequent change in intimacy and confirmed the concurrent association of change in intimacy and symptoms found before (see Appendix D, Supplemental Digital Content, http://links.lww.com/PSYMED/A41).

DISCUSSION OF THE EMPIRICAL STUDY

The current study provided empirical support for the protective effect of physical intimacy on somatic symptoms in everyday life and was consistent with prior research (25,26,33,

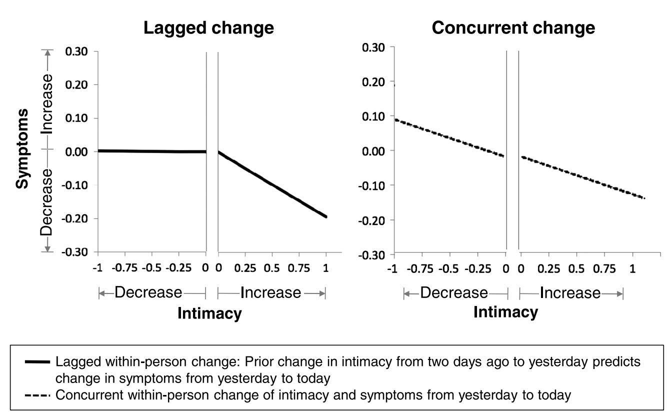

Figure 1. Within-person change in intimacy predicts within-person change in symptoms. The left panel for lagged change shows asymmetric effects: Prior intimacy decrease is unrelated to subsequent symptom change, but when prior intimacy increases, subsequent symptoms decrease. The right panel for concurrent change shows symmetric effects: Intimacy decrease is associated with symptom increase, and intimacy increase is associated with symptom decrease.

40,73). a) The study established temporal order in the link between physical intimacy and symptoms. Prior within-person change in intimacy predicted subsequent change in symptoms: When a person's intimacy increased from one day to the next day (e.g., from Monday to Tuesday), then symptoms decreased during the following days (e.g., from Tuesday to Wednesday). The effects of prior change in intimacy held when adjusting for concurrent change in intimacy. b) Concurrent change in intimacy was associated with change in symptoms: When a person's intimacy increased from one day to the next day, symptoms decreased in the same period. c) The study also found evidence for asymmetric effects of prior change in intimacy on symptom change: Increasing intimacy predicted fewer subsequent symptoms, whereas decreasing intimacy was unrelated to subsequent symptoms.

This study is the first to our knowledge to show that naturally occurring increases in physical intimacy predict subsequent decreases in somatic symptoms within persons. Prior laboratory studies had already found support for lasting effects of intimacy on symptoms (74,82–84). This study demonstrates that these effects occur in real life as well, demonstrating their ecological validity. Analyses that tested the reversed effect of prior change in symptoms on subsequent change in intimacy did not bring evidence for a link in the reverse direction. This finding is not surprising in a mostly healthy sample but would be unexpected in patient samples where symptoms such as pain influence relationship functioning (92).

Limitations of the Current Study

The empirical study has several limitations. First, an important limitation of what studies in daily life can capture is how well the chosen time interval matches the speed of the processes of interest (also called an aliasing effect). If intimacy and symptoms are only measured once per day, as in this empirical study, the design does not allow for capturing very fast processes. Future studies with shorter intervals are necessary to capture the temporal order of faster processes. Second, cross-lagged analyses can help to establish temporal order in the link between social relationships and health but they cannot capture causality. Therefore, concurrent change is best interpreted with bidirectional causation in mind, as in this empirical study: Increased intimacy should have immediate protective effects on somatic symptoms, as previous experiments have shown (25,26), and should therefore lead to lower somatic symptoms on the same day. However, increased symptoms should also lead to immediately decreased intimacy. An individual experiencing physical symptoms will sometimes withdraw from the partner, and a responsive partner would give the symptomatic person space to recover and lower demands for intimacy. For example, among women with metastatic breast cancer, more pain was associated with greater relationship interference (92). In our sample of healthy community couples, we did not find evidence for a lagged effect of symptoms on intimacy, but we cannot rule out same-day effects of symptoms on intimacy. Further research with daily-life interventions and experiments will be needed to draw conclusions on causality.

Third, the analyses focused on establishing the within-person effects of intimacy on health but did not address potential moderators and mediating processes. Potential physiological mediators are changes in cardiovascular function, neuroendocrine function, immune function, and their interactions (23,27,28), with oxytocin release during physical intimacy as a possible origin of modulated physiological activity (33,40,65,74–76, 78–80). In addition to neuroendocrine pathways, there are many other parallel and nonredundant psychological pathways that might mediate the link between physical intimacy and somatic symptoms. For example, physical intimacy may shift attention away from interoception and symptoms (93) and improve mood (70), relationship satisfaction (72), feelings of support, social engagement and companionship, and access to resources and material goods (15). All these mediating processes could also contribute to explaining the within-person effects of physical intimacy on symptoms. Further research in daily life is needed to better understand moderators and mediating pathways that might bring about the effects of physical intimacy on symptoms. These studies will need to reflect an interest in mediators and moderators in their design: Studies with adequate power that measure a range of mediators and moderators and are designed to match measurement times to the hypothesized speed and timing of mediating processes will be crucial for a better understanding.

Fourth, daily-life researchers need to carefully consider limitations of generalizability. Often, couples who are higher in socioeconomic status and relationship satisfaction are more willing to participate, as in the current study. However, there are encouraging examples of studies in daily life using samples with low socioeconomic status (e.g., substance users on methadone substitution (94)); the field could benefit from their valuable experiences to address challenges of recruitment and retention. Finally, the empirical study had self-reported symptoms as the outcome. These symptoms could be reported owing to actual symptom occurrence, symptom experience, or symptom reporting biases. A short recall interval makes memory bias an unlikely explanation of the results. However, symptom experience and symptom occurrence are hard to distinguish. Future experimental studies (e.g., with experimentally controlled symptoms such as pain in a cold pressor task) will help in addressing these questions.

GENERAL DISCUSSION

Theoretical and Practical Implications of Research in Daily Life

The research reviewed suggests that close relationships can influence health on a daily basis. Several types of social interactions seem to influence health outcomes: social support, social influence/social control, social engagement, companionship, and person-to-person contact (15). Because so far there is only a limited number of studies of relationships and health in daily life, three main questions are largely unanswered: a) Which types of health-relevant social interactions occur—separately and jointly—in daily life and in which patterns? For example, it is unclear if social interactions such as social support, control, and companionship co-occur with one another and with the varying forms of physical intimacy and affection—such as holding hands, touching, hugging, kissing, and sexual intercourse. b) Which effects do these social interactions have on health in daily life? For example, it is unclear if physical intimacy and social support have independent effects on health, what size they are, and if they interact. c) Which physiological pathways are most influential? Research in daily life is particularly well suited for answering these questions because it is useful for capturing time-varying processes, disentangling between-person and within-person variance, and establishing temporal order with cross-lagged analyses.

Daily-Life Research Is Useful for Capturing Time-Varying Processes

Many variables of interest in studying close relationships and health vary over time. However, recalling time-varying processes can be a challenge. Short recall periods can help to minimize problems of estimation, limitations of memory, and bias in recall (4,95,96,97). End-of-day reports keep participant burden low; this frequent measurement design allows for running studies of relationships and health over several weeks while keeping recall intervals small.

Daily-Life Research Is Useful for Disentangling Between-Person and Within-Person Effects

If a research team has managed to capture time-varying processes, the next challenge is to disentangle between-person and within-person effects for health and relationship phenomena. For example, some persons (e.g., women compared to men) typically show higher intimacy than others do (between-person variability), but usually persons also fluctuate over time around their typical level of intimacy (within-person variability). Between-person and within-person effects can have very different effect sizes and even differ in sign. But so far, a lot of researchers, including the authors, have neglected to carefully distinguish within-person and between-person effects in longitudinal designs (11,98,99). Neglecting to explicitly distinguish within-person processes from between-person effects—theoretically and statistically—can result in a conceptual error known as "ecological fallacy" (i.e., aggregation bias (100)) and might lead to biased conclusions. Analyses that focus on within-person variation rule out uncontrolled between-person influences as alternative explanations for a given independent variable. One way to do this is by using a "change predicting change" analysis where change in predictor variables is used to explain a change in outcome (90).

Researchers undertake longitudinal studies often in hopes of capturing within-person change. Within-person change in daily life can provide evidence for temporal order and potential direction of causality, with the benefit of external validity. In this sense, within-person change in studies of daily life can deliver strong arguments for conducting experimental and intervention studies. Finding lagged change, that is, a certain predictor changes and an outcome of interest changes subsequently within the same person, is particularly interesting: The temporal order of lagged change is promising for further tests of causal relationships. Finding concurrent change, that is, a certain predictor changes and an outcome of interest changes at the same time within the same person, provides weaker but still encouraging evidence to further explore temporal order and direction of causality because the two variables are closely associated in time over and above stable person characteristics.

In sum, it is difficult to establish causality in studies of close relationships and health. Random assignment of close relationships is often not feasible. But many close relationships show considerable natural fluctuations allowing researchers to study how these relationship changes affect health. If researchers use these data fully, they can disaggregate within-person and between-person effects and learn about temporal order. In addition, intervention studies that increase positive social interactions are beneficial (33). It would be great to study how day-to-day effects unfold over time. Studying close relationships and health in daily life—with both observational studies and field experiments—has enormous potential to help us better understand the processes linking relationships and health.

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