Intimacy as Related to Cortisol Reactivity and Recovery in Couples Undergoing Psychosocial Stress

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ABSTRACT

Objective: The importance of recovery from stress is evident in times of high prevalence of stress-related diseases. Intimacy has been found to buffer psychobiological stress reactivity, suggesting that emotional and physical closeness might trigger biological mechanisms that underlie the health-beneficial effects of couple relationships. Here, we investigated whether couples' spontaneous expression of intimacy before and after psychosocial stress exposure in the laboratory reduced cortisol reactivity and accelerated recovery.

Methods: Data from 183 couples (366 individuals) were analyzed. Couples were randomly assigned to one of the following three experimental conditions: only the female partner ($n = 62$), only the male partner ($n = 61$), or both partners were stressed in parallel ($n = 60$) with the Trier Social Stress Test. Couples' behavior was videotaped and coded for expressions of intimacy, and saliva samples were taken repeatedly (nine times) to analyze cortisol levels before and after stress. Data were analyzed using hierarchical linear modeling.

Results: Observed partner intimacy reduced cortisol responses to stress in women ($B = -0.016$, SE = 0.006, $p = .008$), although this effect was eliminated among women using oral contraceptives. Observed partner intimacy also reliably accelerated cortisol recovery in men ($B = -0.002$, SE = 0.001, $p = .023$) and women ($B = -0.002$, SE = 0.001, $p = .016$).

Conclusions: Spontaneous nonverbal expressions of intimacy seem to regulate the effects of acute environmental demands on established biological indices of stress response.

Key words: couples, cortisol, dyadic coping, intimacy, stress reactivity, stress recovery.

INTRODUCTION

The health-promoting effects of social support and even the mere perception of affiliation have long been recognized (1–5). Socially integrated people live healthier and longer lives (6), presumably because social bonds provide individuals with understanding and stable sources of support that—besides improved health behavior and positive affect—promote reduced psychobiological stress reactivity (7). In line with this, higher-quality relationships increase longevity (8), suggesting that positive and supportive interactions in happy couples might be driving this effect on an emotional and behavioral level (9). Indeed, an impressive number of studies have confirmed the effects of social support or dyadic coping on stress responsiveness, including biological indices of stress outcomes (10). For example, when one partner is instructed to provide social support while his or her mate faces a standard laboratory stress task, this support seems to consistently ameliorate cardiovascular and endocrine stress responses, particularly among men (11,12).

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Importantly, beyond the general exchange of positive behaviors, recent research suggests intimacy as an intriguing factor to modulate stress responses and, thereby, improving health. Intimacy, a highly elaborated affective, cognitive, and behavioral concept within the social sciences describes a dynamic process characterized by reciprocal emotional disclosure and responsiveness (13) during several social interactions (14). Intimacy is an integral part of couple relationships, and couples evaluate the mutual process of building intimacy as a central component of their relationship satisfaction. Specifically, when couples are confronted with stress, mutual support, or common dyadic coping can enhance feelings of intimacy, with intimacy behavior, such as touch, emerging as important nonverbal aspect of common dyadic coping (15,16). Above this, intimacy behavior (e.g., eye contact, hand holding, caressing) can serve as a symbol for emotional closeness and as a safety signal. With (social) safety signals being interpreted

ANOVA = analysis of variance, **HPA** = hypothalamic-pituitary-adrenal, **MDBF** = Multidimensional Mood Questionnaire, **OC** = oral contraception, **TSST** = Trier Social Stress Test

SDC Supplemental Content

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Received for publication October 4, 2017; revision received June 29, 2018.

DOI: 10.1097/PSY.0000000000000633

as potent regulators of affective and physiological stress responses (see, (17,18)) intimacy-related processes might be candidates for explaining the specific effects of couple relationships on health. To serve as such a link, intimacy behavior needs to symbolize affective closeness in a way that is easily understandable for both partners. Above this, intimacy behavior would have to show effects on health-related systems. This does indeed seem to be the case: newly emerging evidence from momentary assessment studies (collection of subjective data via smartphone-prompts, sometimes in parallel to physiological measures) in everyday life suggests that affective social interactions and intimacy behavior can increase positive affect (19,20) and reduce somatic symptoms (21), blood pressure (22), and cortisol levels (23), the latter serving as an indicator of endocrine stress reactivity. More specifically, experimental research suggests that instructed warm touch between partners can reduce cardiovascular and endocrine stress responses (12,24). However, momentary assessments and experimental research both face methodological limitations; whereas spontaneous displays of affection in couples' everyday life might only occur during (and buffer) minor stressors, instructed physical contact in the laboratory might not necessarily correspond to individual needs during a stressful situation. Thus, although momentary assessment studies might be difficult to interpret with regard to the stressful situation, laboratory designs face limited validity with regard to intimacy. Therefore, we sought to investigate naturally occurring and uninstructed interaction behavior between partners before standard stress in the laboratory. We focused on intimacy behavior from the partner in its influence on stress reactivity and recovery from stress. Therefore, behavior sequences were videotaped and later coded for spontaneous intimacy behavior.

In light of high prevalence of burnout, chronic cardiovascular disease, and other stress-related disorders, recovery from daily stressors plays a pivotal role and is considered an important predictor of long-term health. It is, thus, not only the response to stress but also the recovery from stress that is of increasing interest in psychobiological research. A slower recovery rate in autonomic and endocrine measures was associated with negative emotional states, such as worry (25–27) and impaired health in the long term (28). In line with this, more recent research suggests that poststress cognitions can influence stress recovery (29,30). This leads us to hypothesize that couples who express more intimacy behavior after stress would recover more quickly from stress. In this context, and to add on data on cardiovascular stress reactivity (27), the dynamics of the hypothalamic-pituitary-adrenal (HPA) axis are of particular interest. The HPA axis is the major endocrine stress-reactivity system and its end-product cortisol mediates immune responses with possible long-term health implications (31). It is, thus, of central interest to investigate HPA axis responses in relation to couple behavior during stress. Despite the relevance of this topic, the impact of social support and positive couple interaction on how fast the HPA axis recovers from stress has only begun to be investigated (32). Based on the previously cited experimental data on social support and touch, both men and women would be expected to benefit from their partner's intimacy behavior before and after stress exposure. However, we are not aware of a study, which tested sex effects on naturally occurring intimacy behavior before or after stress under standard laboratory conditions. Therefore, we conducted an experimental study with couples, randomly assigned to the three following conditions: only the woman was stressed, only the man was stressed, or both partners were stressed in parallel. We focused on endocrine reactivity and recovery separately after an acute, couple–external stressor. We were interested in couples' spontaneously expressed intimacy and whether both men and women would benefit from their partner's intimacy. Specifically, we hypothesized that (1) the partner's higher intimacy behavior before stress would be associated with lower endocrine stress reactivity (expressed through lower cortisol responses) and that (2) the partner's higher intimacy behavior after stress would accelerate recovery from stress (indicated through faster cortisol decreases after stress exposure). Couples were videotaped during interaction before and after the stress induction, and intimacy was coded when kissing, caressing, active hugging, or active hand holding occurred. Data were analyzed by using multilevel modeling for curve estimations.

METHODS

Participants

The study was conducted with 198 heterosexual healthy couples between March 2008 and November 2009. All couples were Swiss German or German speaking, and they all gave written informed consent. Mean (SD) age was 26.3 (5.6) years for women and 28.4 (6.2) years for men. Participants were recruited through ads in newspapers, online announcements, and printed flyers, whereas 871 couples contacted the study team via e-mail or telephone. First, the study information was sent, and although 240 couples did not respond after a first contact anymore, 631 couples underwent a screening to check the match for the following criteria: age between 20 and 45 years (= adult couples), women premenopausal (to control for reproductive phase–related variations in cortisol outcomes), exclusively dating for at least 1 year, both partners willing to participate, no smoking (or <10 cigarettes per day), no alcohol or other drug abuse, no chronic medical or psychological diseases and no medication except oral contraception (OC) in women, and a fluent knowledge of German or Swiss German to facilitate observational coding. To control for menstrual cycle effects on cortisol, naturally cycling women (named "nonusers" in the following) were screened for regular menstrual cycle. All women were investigated in their luteal phase (day 17–24). We assessed 129 women with OC use and 69 nonusers (for previously reported influence of OC use on endocrine stress response, see studies (33–35)).

Before participation, couples were randomly assigned to one of the three conditions (group 1 = woman stressed; group 2 = man stressed; group 3 = both partners stressed). Fifteen couples had to be excluded from statistical analyses because of intake of an antidepressant drug (1 couple), noncompliance (1 couple), extreme outliers in their cortisol response (±2 standard deviations in *all* saliva samples; 7 couples), or no video data because of technical problems (6 couples). Thus, the final sample consisted of 183 couples, including 121 OC users and 62 nonusers. To simplify, we use the term OC for every kind of hormonal birth control method used by the participating women (for detailed overview, see Table S1, Supplemental Digital Content, http://links.lww.com/PSYMED/A512).

Procedures

Every couple was scheduled for an afternoon session starting between 4:00 PM and 5:30 PM. Participants were instructed to abstain from alcoholic or any pharmaceutical substances after the night before, to have a usual breakfast and lunch, and to abstain from caffeinated drinks after noon on the day of the appointment.

After providing informed consent, the first saliva sample was taken to measure baseline cortisol levels (−20 minutes before stress). Altogether, nine saliva samples were taken to measure cortisol levels before and after stress.

The study's main room was furnished with a couch, a video camera in front of it, and two computers to fill out questionnaires online. Couples were informed that they would be videotaped during the study and that they had the option to discontinue the laboratory experiment at any time if requested. None of the couples made use of this opportunity. Thus, during the entire experimental session, a video camera recorded the couple, but only predefined interaction sequences were coded afterward (described in detail hereinafter).

Trier Social Stress Test

According to the experimental condition, one partner or both partners participated in the "Trier Social Stress Test" (TSST) (36). After being introduced to the audience, the stressed participant had 5 minutes to prepare a free speech for the job interview in a separate room. The job interview started, followed by a mental arithmetic task. Including the introductions, the TSST lasted 15 minutes. The stressed participants in group 3 underwent the TSST simultaneously in separate rooms. In the conditions with only one partner stressed, the nonstressed partner was left alone in the initial room seated on a couch with the option to read a magazine.

Couple Interaction Sequences

Before the TSST, the couple was left alone for 8 minutes while their communication and interaction (interaction pre-TSST) were videotaped. Couple interactions were unstructured; the only instruction was to remain seated on the couch. At this time, the couple already knew that a job interview would be after but was not informed about which partner would be involved (group 1, 2, 3).

After the TSST, the investigators left the room again for 8 minutes (interaction post). The same as before stress, no specific advice for support or other behavior was given. After this second interaction sequence, participants filled out the mood state questionnaire. One hour after the TSST and after collection of the final saliva sample, couples were debriefed and given CHF 100 for participation.

All participants provided written informed consent. In addition, they were asked to give informed consent for the videotaped sequences (for coding and calculations). All couples agreed to this. The study was approved by the ethics committee of the University of Zurich and the Canton of Zurich.

Endocrine Measures

To measure cortisol levels, nine saliva samples were collected before (1, –20 minutes; 2, –10 minutes; 3, –1 minute) and after TSST (4, +1 minute; 5, +15 minutes; 6, +20 minutes; 7, +35 minutes; 8, +50 minutes; 9, +60 minutes) from each stressed and waiting participant, respectively. Measures 1 to 5 were used to calculate cortisol stress reactivity, measures 5 to 9 were used to calculate cortisol recovery. Commercially available sampling devices were used (Salivette Sarstedt, Nümbrecht-Rommelsdorf, Germany), which contain a synthetic swab specially designed for cortisol level determination in the saliva (37). After each experimental session, saliva samples were stored at −20°C. Saliva samples were thawed and spun at 3000 rpm for 10 minutes to obtain 0.5 to 1.0 ml of clear saliva with low viscosity. Saliva cortisol concentrations were determined by a commercially available chemiluminescence immunoassay (CLIA; IBL Hamburg, Germany) at Dresden Lab Services, Dresden, Germany. The coefficient of interassay variance was 8.4% and for intra-assay variance 4.6%.

Behavioral Measures

Coding of Intimacy Behavior

The 8 minutes of unstructured couple interaction (interactions pre-TSST and post-TSST) were videotaped and rated according to the System to Evaluate Dyadic Coping (38), which was developed to code support interactions in intimate relationships. For the present analysis, we focused on couples' exchange of physical, nonverbal intimacy including kissing, caressing, active hugging, or active hand holding, which is abbreviated to *intimacy* in the following paragraphs. Raters coded every 10 seconds of the two 8-minute interaction segments (1) for each individual's expression of any of the described behaviors and (0) for no intimacy or avoiding intimacy, respectively. This coding resulted in six codes per minute for 8 minutes (0 or 1), which were summarized to a relative frequency of intimacy behavior (resulting in a possible range of minimum of 0 to a maximum of 48).

The category intimacy was specifically developed for this study. Two independent raters were intensively trained. They were blind to the content of the experimental study and had never attended to a TSST. The concordance of the ratings between the two raters was good with Cohen's κ of 0.92 (10% of the tapes were coded by both raters). Intimacy scores were calculated for pre-TSST and post-TSST interaction phases. The partner's display of intimacy ("partner intimacy") was then included as a predictor of individuals cortisol stress reactivity and recovery.

Intimacy scores before and after stress were correlated (r = .483) and scores from pre-TSST and post-TSST were collapsed for the calculation of overall individual intimacy scores and the comparison of individuals, who expressed any intimacy with those who did not.

Questionnaires

State mood was implemented as a control measure and assessed with the *Multidimensional Mood Questionnaire* (MDBF, (39)), which is especially suited for repeated measures within several minutes or hours. Twelve items were rated on five-point scales, ranging from 1 ("not at all") to 5 ("very strongly"). Factor analysis revealed the following three scales: elevated versus depressed mood, wakefulness versus sleepiness, and calmness versus restlessness. The MDBF was administered four times (baseline, −1-min, +1-min, +15-min TSST).

In addition to the state questionnaire, we used the *Relationship Assessment Scale* (40), German version by (41) to assess individual relationship satisfaction. Seven items were rated on a five-point Likert scale. Higher ratings represented higher satisfaction. Internal consistency of the averaged scales was reasonable with α value of .74 for women and .71 for men.

Statistical Analyses

Manipulation checks to test for effects of stress manipulation were performed with either t tests to compare means or analyses of variance (ANOVAs) with repeated measures (Greenhouse–Geisser corrected). To test the main hypotheses, we used hierarchical linear modeling (HLM, Version 6.03, (42)), to account for the hierarchically nested data structure. With this approach, within and between-individual variation of the hormone cortisol is taken into account (43).

Because we were interested in the effects of intimacy on cortisol stress reactivity and recovery, we focused on the data from women in group 1, men in group 2, and women and men in group 3. With "stressed women," data from group 1 and 3 and with "stressed men," data from group 2 and 3 were analyzed. Consequently, only with couples in group 3 data from both partners were analyzed, and it was not possible to include a third (couple) level in hierarchical linear modeling.

The first level includes repeated measures of salivary cortisol (individual dependent variables) and the second-level concerns individual characteristics. The two slopes of cortisol reactivity and cortisol recovery were computed separately in accordance with the following level 1 equation:

$$\mathrm{CORT}_{ti} = \pi_{0i} + \pi_{1i}(\mathrm{time}) + e_i$$

CORT_{ti} indicates repeated cortisol measures (individual i at time t). The coefficient π_{0i} represents the cortisol level at the beginning (baseline for cortisol reactivity, fifth saliva sample for cortisol recovery). With π_{1i} (time), the reactivity slope (saliva samples 1–5) or recovery slope (saliva samples 5–9) were computed accounting for the varying minute intervals between saliva samples; e_i represents level 1 random effect. Restricted maximum

likelihood was used for calculations. Cortisol data were normally distributed and entered as raw data.

Models were estimated for men and women separately to avoid too many interactions and to simplify interpretation. On level 2, we added condition (contrast coded, −1 = stressed alone; 1 = both partners stressed), age (grand-mean centered), and OC (only in women; dummy coded: 0 = nonusers; 1 = OC users) with the intercept and with the slope to control for possible effects. Finally, we entered partner intimacy and, in women, the interaction of OC with partner intimacy to test for moderation effects. Partner intimacy was included as a cross-level interaction term when calculating the reactivity and recovery slopes.

RESULTS

Sample Characteristics

Characteristics of the final sample (N = 183 couples) are presented for each experimental condition (Table 1). No significant condition or sex by condition differences were found in age, body mass index (BMI), duration of relationship, or trait questionnaire measures including relationship satisfaction ($F \leq 1.6$, $p \geq .21$). There were no sex differences in terms of duration of relationship. In comparison with men, women were significantly younger and had a lower BMI. Participants reported high relationship satisfaction with low variance (*Relationship Assessment Scale*, M (SD) = 4.4 (0.4), range = 1–5).

The majority of our sample was Swiss (women, 71.2%; men, 74.2%) or German (women, 20.2%; men, 17.7%) and either attending school (women, 54.5%; men, 41.4%) or working (women, 30.3%; men, 42.9%).

Psychological Manipulation Check

MDBF scores are displayed in Table 2. State mood significantly changed for stressed participants during the experiment (repeated measures ANOVA, main effect of time: F(1.86, 450.89) = 124.71, MSE = 5.65, $p \leq .001$, $\eta_p^2 = .340$); they reported significantly worse mood after the TSST in comparison with nonstressed participants (time by stress versus nonstress condition: F(2.12, 769.78) = 62.33, MSE = 4.11, $p \leq .001$, $\eta_p^2 = .146$). Stressed women displayed a greater decline in mood after the TSST than stressed men (time by sex: F(1.90, 458.45) = 9.00, MSE = 5.35, $p \leq .001$, $\eta_p^2 = .036$). Among nonstressed participants, there was no change in mood over time (F(2.39, 291.65) = 1.78, MSE = 2.13, $p = .163$, $\eta_p^2 = .014$), no effect of sex (F(1, 121) = 0.02, MSE = 10.81, $p = .893$, $\eta_p^2 < .001$), and no sex by time effect (F(2.40, 290.77) = 1.11, MSE = 1.00, $p = .340$, $\eta_p^2 = .009$).

Physiological Manipulation Check

A one-way repeated measures analysis of variance revealed significant increases in salivary free cortisol levels (baseline = TSST +15 minutes) for all stressed participants, main effect of time F(1.30, 315.59) = 237.28, MSE = 58.10, $p \leq .001$, $\eta_p^2 = .495$. In addition, there was a significant sex by time interaction effect (F(1.37, 329.01) = 41.33, MSE = 47.57, $p \leq .001$, $\eta_p^2 = .146$) and a significant OC by time interaction effect (F(1.34, 160.77) = 7.53, MSE = 30.44, $p = .003$, $\eta_p^2 = .059$) in women. These findings are consistent with previous research (33,34); for review see, e.g., Kudielka et al. (44).

Basal cortisol levels (sample 1, −20 min) were significantly lower in women (M (SD) = 5.89 (3.40) nmol/l; see cortisol means and SDs, Table 3) than in men (M (SD) = 7.12 (4.31) nmol/l, t = −3.015, $p = .003$, 95% CI = −2.02 to −0.43). No significant impact of OC use on cortisol baseline could be detected in women (nonusers: M (SD) = 5.80 (3.10) nmol/l, OC users: M (SD) = 5.94 (3.56) nmol/l; t = −0.248, $p = .804$, 95% CI = −1.18 to −0.92). Average absolute increases in salivary cortisol in response to stress were 14.38 nmol/l in stressed men and 7.16 nmol/l in stressed women. Nonstressed participants showed a significant decrease in the cortisol level during the experiment (women: F(1.76, 105.41) = 11.53, MSE = 13.83, $p < .001$, $\eta_p^2 = .161$; men: F(1.65, 100.56) = 55.59, MSE = 23.17, $p < .001$, $\eta_p^2 = .477$). In addition to the time effect, there was a time by OC effect by trend in women: nonusers showed a faster decrease in cortisol (F(1.71, 100.78) = 2.91, MSE = 13.79, $p = .067$, $\eta_p^2 = .047$).

Effects of Partner Intimacy on Cortisol Stress Reactivity and Recovery

Men's and women's intimacy scores are presented in Table 4 and results of the cortisol analyses concerning *stress reactivity* are presented in Table 5. Baseline cortisol level was 4.477 nmol/l for

TABLE 1. Description of Couples' Characteristics in the Three Experimental Groups

	Group 1[a] (Woman Stressed)		Group 2[b] (Man Stressed)		Group 3[c] (Both Partners Stressed)				
Characteristic	Women	Men	Women	Men	Women	Men	Sex Effect	Group Effect	Sex by Group Effect
Age, y	26.1 (5.3)	28.4 (6.4)	25.8 (5.5)	28.0 (6.4)	26.2 (5.4)	27.9 (5.6)	11.704**	.150	.130
BMI, kg/m^2	21.0 (2.1)	23.8 (2.6)	20.9 (2.3)	23.1 (2.6)	20.7 (2.4)	22.8 (2.0)	91.084***	2.457	.698
Duration of relationship, y	4.3 (3.6)	4.4 (3.6)	4.4 (3.5)	4.5 (3.4)	3.8 (3.9)	3.9 (4.0)	.033	.841	.002

BMI = body mass index.

Shown are M (SD) for characteristics and F values for effects analyzed by ANOVA. Neither group nor sex by group effects were found.

** $p < .01$.

*** $p < .001$.

[a] n = 62 couples.

[b] n = 61 couples.

[c] n = 60 couples.

TABLE 2. Sex-Specific State Mood Before and After TSST

Variable	Women			Men		
	All[a]	Stressed[b]	Nonstressed[c]	All[d]	Stressed[e]	Nonstressed[f]
MDBF baseline	17.42 (2.35)	17.46 (2.13)	17.33 (2.75)	17.43 (1.79)	17.35 (1.83)	17.60 (1.72)
MDBF pre-TSST	17.31 (2.23)	17.33 (2.11)	17.28 (2.47)	17.45 (1.81)	17.42 (1.84)	17.51 (1.75)
MDBF post-TSST		13.89 (4.04)	17.84 (1.80)		15.34 (2.94)	17.68 (1.72)
MDBF +15-min TSST		16.98 (2.24)	17.67 (1.78)		17.13 (2.10)	17.48 (1.67)

MDBF = state mood, measured 4 times; TSST = Trier Social Stress Test.

Data are presented as M (SD).

[a] $n = 183$.

[b] $n = 122$.

[c] $n = 61$.

[d] $n = 183$.

[e] $n = 121$.

[f] $n = 62$.

stressed women in group 1, nonusers, and of mean age. The difference to OC users was 0.858, which was not significant ($p = .238$). Neither the effect of condition nor age on cortisol was significantly different from zero at baseline. In addition, the model shows a significant influence of age in men's baseline cortisol level (the older, the lower the baseline).

Mean cortisol stress reactivity slope was 0.177 nmol/l for stressed women and 0.267 nmol/l for stressed men (in group 1, at mean age, receiving zero intimacy from the partner, and nonusers in women). Increases in cortisol levels were significantly reduced by partner intimacy among women (−0.016, $p = .008$) but not among men (−0.005, $p = .262$). The significant, positive interaction coefficient (partner intimacy by OC) in women signifies that this effect of intimacy is only present (significantly different from zero) for nonusers' cortisol increase. The OC users' increase in cortisol levels after stress induction were significantly reduced by OC itself ($p = .004$). In addition, age had a marginal influence ($p = .098$) on women's cortisol increase; the negative coefficient indicates a slightly slower increase for older women.

We used a similar approach to model cortisol *stress recovery* phases. In addition to the control variables in the previous model, the measure 3 one minute before TSST (grand-mean centered) was included with the peak and slope in the recovery model (Table 6) to control for individual cortisol levels.

Stressed women (OC nonusers) displayed a mean peak of 15.050 nmol/l, and stressed men showed a mean peak of 22.273 nmol/l. The significant influence of saliva sample 3 one

TABLE 3. Cortisol Levels at Each Measure

Cortisol	Women				Men	
	OC Users		Non-OC Users			
	Stressed[a]	Nonstressed[b]	Stressed[c]	Nonstressed[d]	Stressed[e]	Nonstressed[f]
1. Baseline (−20 min before TSST)	5.91 (4.02)	5.98 (2.47)	5.67 (2.60)	6.08 (4.04)	6.68 (4.08)	7.96 (4.66)
2. −10 min before TSST	6.51 (4.99)	6.69 (3.17)	6.30 (3.15)	6.02 (3.46)	8.16 (5.41)	9.45 (6.13)
3. −1 min before TSST	6.39 (4.84)	6.80 (3.70)	5.95 (3.17)	5.37 (3.19)	7.71 (5.29)	8.12 (5.15)
4. +1 min after TSST	7.20 (4.58)	6.26 (3.13)	7.81 (3.79)	4.42 (2.41)	11.73 (6.97)	6.16 (3.34)
5. +15 min after TSST	11.07 (6.39)	5.76 (2.85)	14.63 (8.60)	4.02 (2.09)	21.20 (11.47)	5.33 (3.20)
6. +20 min after TSST	11.56 (6.74)	5.50 (2.62)	14.25 (8.79)	3.61 (1.87)	20.78 (11.95)	4.99 (2.87)
7. +35 min after TSST	10.07 (5.97)	5.47 (2.48)	10.41 (6.37)	3.32 (1.54)	14.11 (8.17)	4.38 (2.39)
8. +50 min after TSST	8.83 (4.73)	5.36 (3.08)	8.34 (5.05)	3.11 (1.37)	10.73 (5.89)	3.94 (2.11)
9. +60 min after TSST	8.21 (4.22)	5.23 (4.23)	7.12 (4.16)	2.98 (1.46)	9.06 (5.01)	3.63 (1.98)

TSST = Trier Social Stress Test; OC = oral contraception.

Date are presented as M (SD). Cortisol assessed in nmol/L, distributions not significantly violated normal distribution.

[a] $n = 80$.

[b] $n = 41$.

[c] $n = 42$.

[d] $n = 20$.

[e] $n = 121$.

[f] $n = 62$.

TABLE 4. Intimacy Behavior Scores

	Women			Men		
Variable	All	Stressed	Nonstressed	All	Stressed	Nonstressed
Intimacy pre-TSST range	1.92 (3.80) 0–24			2.01 (3.72) 0–26		
Intimacy post-TSST range		1.93 (3.86) 0–27	2.77 (4.58) 0–27		1.96 (2.88) 0–13	3.90 (5.65) 0–32

TSST = Trier Social Stress Test.

Data are presented as M (SD).

minute before TSST (in men and women) suggests that the higher the cortisol level before stress, the higher the peak after stress. In addition, OC users showed a significantly lower peak than nonusers (−3.738 nmol/l, $p \leq .001$). The slope during recovery was −0.173 nmol/l for stressed women and −0.305 nmol/l for stressed men. The negative coefficients (−0.004 for stressed women, −0.016 for stressed men) signify a faster recovery for participants with higher measures pre-TSST and higher peaks post-TSST.

Regarding partner intimacy, we found significantly negative coefficients for men (−0.002, $p = .023$) and women (−0.002, $p = .016$), indicating that partner intimacy accelerated the cortisol recovery from stress. In Figure 1, mean cortisol levels are shown for women and men with either high or low intimacy scores (median split, data not used for the statistical analyses). The interaction term partner intimacy by OC was not significant ($p = .245$), indicating that OC did not moderate the effect of partner intimacy on cortisol recovery.

Condition and age did not significantly influence either the peak or the slope of the cortisol recovery.

Comparison of Participants Showing Intimacy or Not

We were also interested in possible overall differences between participants showing any intimacy in comparison with participants who did not display intimacy behavior during the two interactions. Therefore, a split variable was created to compare participants who expressed 0 = no intimacy and 1 = who showed at least one measureable display of affection (i.e., hugging, kissing, hand holding, etc.) during at least one of the two interactions. Results of the *t* test (except for marital status and number of children we used Mann–Whitney *U* test) are available as Supplemental Digital Content, http://links.lww.com/PSYMED/A512 (see Table S2, Supplemental Digital Content, http://links.lww.com/PSYMED/A512).

Age, duration of the relationship, and relationship satisfaction differed significantly in both men and women between the two groups. Participants showing no intimacy at all were older, longer in the relationship, and reported lower values in relationship satisfaction. Men who showed no intimacy were more likely to be married and had more children. All other trait variables were not significantly different between the two groups.

DISCUSSION

Intimacy, a defining feature of close relationships, has been proposed a mediator of the health-beneficial effects of couple relationships. Particularly, intimacy may play a central role in the stress-coping process in couples and thereby regulate stress-related emotions in the partners. Emotional, cognitive, and physical aspects

TABLE 5. Hierarchical Linear Models Predicting Cortisol Reactivity to Stress in Stressed Women and Stressed Men Using Restricted Maximum Likelihood Estimation

	Stressed Women[a]			Stressed Men[b]		
Fixed Effects	Unstand. Coeff.	*T* Ratio, *df*	SE, *p*	Unstand. Coeff.	*T* Ratio, *df*	SE, *p*
Baseline						
Intercept	4.477	6.722, 117	0.555, <.001	4.898	8.485, 117	0.557, <.001
Group	−0.313	−0.814, 117	0.384, .418	0.081	0.099, 117	0.819, .922
OC	0.858	1.195, 117	0.718, .235			
Age	−0.035	−0.577, 117	0.061, .565	−0.157	−2.045, 117	0.077, .043
Time slope						
Intercept	0.177	5.899, 115	0.029, <.001	0.267	10.248, 116	0.026, <.001
Group	0.000	0.024, 115	0.011, .981	−0.025	−0.719, 116	0.035, .473
OC	−0.104	−2.967, 115	0.035, .004			
Age	−0.004	−1.665, 115	0.003, .098	−0.000	−0.030, 116	0.003, .976
Partner intimacy	−0.016	−2.699, 115	0.006, .008	−0.005	−1.128, 116	0.004, .262
Partner intimacy by OC	0.015	2.308, 115	0.006, .023			

OC = oral contraception; Intimacy = amount of intimacy, the partner expressed during the interaction pre-TSST.

Random slopes model with robust standard errors.

[a] $n = 122$ (80 OC users, 42 nonusers).

[b] $n = 121$.

TABLE 6. Hierarchical Linear Models Predicting Cortisol Recovery to Stress in Stressed Women and Stressed Men Using Restricted Maximum Likelihood Estimation

	Stressed Women[a]			Stressed Men[b]		
Fixed Effects	Unstand. Coeff.	*T* Ratio, *df*	SE, *p*	Unstand. Coeff.	*T* Ratio, *df*	SE, *p*
Peak						
Intercept	15.050	9.598, 116	1.436, <.001	22.273	17.790, 116	1.252, <.001
Group	−0.611	−1.000, 116	0.611, .320	−1.947	−1.103, 116	1.766, .273
OC	−3.738	−2.263, 116	1.652, .025			
Saliva sample 3	0.662	4.874, 116	0.136, <.001	1.275	7.734, 116	0.165, <.001
Age	−0.093	−0.712, 116	0.130, .478	0.069	0.433, 116	0.159, .665
Time slope						
Intercept	−0.173	−7.765, 114	0.021, <.001	−0.305	−14.652, 115	0.021, <.001
Group	0.006	0.738, 114	0.008, .462	0.031	1.082, 115	0.028, .282
OC	0.098	4.198, 114	0.023, <.001			
Saliva sample 3	−0.004	−2.657, 114	0.002, .009	−0.016	−5.052, 115	0.003, <.001
Age	0.000	0.289, 114	0.002, .773	0.001	0.485, 115	0.003, .628
Partner intimacy	−0.002	−2.452, 114	0.001, .016	−0.002	−2.302, 115	0.001, .023
Partner intimacy by OC	0.002	1.169, 114	0.002, .245			

OC = oral contraception; Partner intimacy = amount of intimacy, the partner expressed during the interaction post-TSST.

Random slopes model with robust SEs.

[a] n = 122 (80 OC users, 42 nonusers).

[b] n = 121.

of intimacy are interwoven, and couples use various forms of touch to symbolize emotional closeness. We focused on these physical aspects of intimacy and investigated whether spontaneous expression of touch and physical proximity in the laboratory before and after a standard couple–external stressor would reduce endocrine stress responses and ameliorate stress recovery in women and men.

Either the woman, the man, or both partners were stressed in parallel with the TSST. Videotaped couple interactions before and after stress induction were coded for spontaneously provided affective physical contact, i.e., hand holding, touch, hugging, kissing, etc., with the sum of these behaviors labeled as intimacy behavior. Results suggest that even a small amount of intimacy behavior received from the partner affected the cortisol response of the stressed participants. Women receiving intimacy behavior before stress showed an attenuated cortisol increase. Oral contraceptive use, however, seemed to reduce this beneficial effect. After stress, both men and women benefited from their partner's expression of intimacy with regard to their cortisol recovery. While in women, this effect did show immediately after stress but no longer

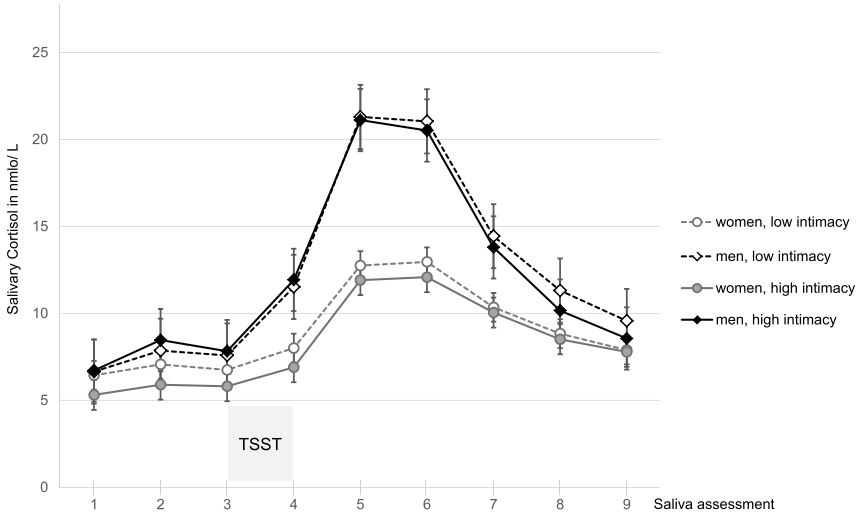

FIGURE 1. Mean cortisol responses to the TSST and cortisol recovery from stress in women (gray) and men (black) after either low intimacy (dotted line) or high intimacy between partners (full line). Color image is available only in online version (www.psychosomaticmedicine.org).

at 1 hour after stress exposure, in men these differences seemed to sustain.

Additional analyses suggest that overall older participants and those in longer (but less happy) relationships were less likely to express any intimacy.

These results are in line with the broad research to suggest that positive relationship interaction may lead to better health outcomes through improvements in cardiovascular, endocrine, and immune functioning (8). While continuous relationship conflict or divorce is associated with poor health outcomes (45), couple interventions seem to reduce cortisol (46) and autonomic stress markers (47). The present data add specificity to this emerging body of work, suggesting that spontaneously expressed physical contact and touch between partners might explain one aspect of how relationships promote better health outcomes. Previous research shows protective effects of instructed physical touch on cardiovascular and endocrine stress responses (12,24). In the present experimental setting, spontaneous and therefore more natural behavior was investigated before and after experimentally induced stress—for the first time, to our knowledge. These data are in line with momentary assessments in everyday life where intimacy had a buffering effect on cortisol levels (23), improved affect (19,20), and reduced somatic symptoms (21).

Our findings strengthen the idea that intimacy behavior is an efficient coping strategy against stress and, indeed, more than half of the couples showed at least some intimacy behavior before and/or after stress. These findings on intimacy are congruent with results on verbal social support in close relationships. Social support provided from the partner can reduce psychobiological stress responses and improve health (for an overview, see (6)). Importantly, other analyses from the present study indicate that the effects of dyadic coping are moderated by sex, the supporter's own stress levels (48), and the support recipient's attachment style (32). Intimacy and couple support share overlapping aspects, and it is interesting that on a descriptive level, stressed men expressed lower levels of intimacy in comparison with men who had not been stressed. In women, no such difference was evident. These data are in line with the results from Bodenmann and colleagues (48) who found sex effects on social support to emotional stress-expression only when the men were stressed.

Although there can be partner support without intimacy as well as intimacy without the aim to support each other, touch by itself can be used as nonverbal (or emotion-focused) support. It is this nonverbal support, which seems to have particular strong effects in women. In a former study and when directly compared with verbal support, instructed touch provided from the partner reduced autonomic and endocrine stress responses in women, whereas verbal support did not (12). It seems plausible that the lack of evaluation or need to perform drives these beneficial effects and makes touch easier to accept than verbal support. Beyond this, nonverbal intimacy behavior might trigger cognitions of safety, belonging, and acceptance. This would be in line with assumptions from social baseline theory (49) that social proximity induces calmness through the perception of safety and attachment. Indeed, although the behavioral expression of intimacy (c.f., (50)) was in the focus of this present analysis, intimacy behavior per se cannot be separated from its emotional and cognitive aspects. We assume that these behaviors express emotional closeness and the perception of "we-ness" and trust in the couple (15,16). This interpretation of intimacy behavior as a nonverbal means to symbolize closeness and safety extends basic research and animal research on the central nervous system effects of touch.

Different emotional qualities can be communicated via touch alone (51,52), and the interpretation of haptic stimulation being a social signal can modulate how this stimulation is evaluated (for an overview, see (53)). A network of brain regions, including the orbitofrontal cortex (54), the medial prefrontal cortex, the dorso anterior cingulate cortex, the insula (55), and the pregenual anterior cingulate cortex (56), seems to be involved in the processing of pleasant social touch. In a seminal study by Coan and colleagues (57), touch served as safety cue and reduced neural threat responses during the anticipation of an electric shock in women. Recently, it was shown that intranasal administration of the neuropeptide oxytocin increased the pleasantness of social touch and enhanced neural responses to touch in the orbitofrontal cortex, the insula, the precuneus, and the pregenual anterior cingulate cortex (58). Oxytocin is a nonapeptide that serves as a neuromodulator and targets several areas in the brain (59,60). Touch and body contact stimulate oxytocin in animals (61–63), and most recently, oxytocin was shown to modulate consolation behavior in voles. After one vole was stressed and separated from the partner, the partner showed increased grooming behavior during reunion—a behavior pattern that could be eliminated through injection of an oxytocin antagonist (64). Given the central role of oxytocin in human stress responsiveness (65,66), social behavior (67–69), and couple behavior in particular (70,71), these findings may link intimacy to psychobiological stress reduction on a neuroendocrine level.

Above these overall effects, our data suggest sex differences in the response to intimacy behavior and a modulation through sex hormones, i.e., hormonal contraception, in women. Tending behavior under stress has been proposed a characteristic for women rather than for men (72). Our findings support this theory in general—men revealed higher cortisol responses to stress than women and women seemed to benefit more from intimacy behavior before stress. However, both men and women expressed intimacy behavior toward their partner and benefited from their partner's caressing after stress. These findings in men are in line with von Dawans (73) who reported tend-and-befriend behavior in male student groups after stress induction. Together, our data support the women's sensitive reaction and ameliorated stress responses toward their partner's intimacy behavior but at the same time suggest accelerated recovery to intimacy in both men and women. Recently, Liu and colleagues (74) reported meta-analytical data that OCs in women reduced reactivity to the TSST. The authors speculate that OCs might affect cortisol binding capacity in women. Our data are in line with these results; however, we have no data on glucocorticoid or mineralocorticoid receptor sensitivity, as an indicator of cortisol binding capacity. Thus, our study's methods and results leave open how exactly reproductive hormones influenced cortisol responses or the interaction with the partner's intimacy behavior in the present sample.

Limitations

By design, this study focused on stress reactivity and recovery to an acute psychosocial laboratory stressor and results cannot be generalized to repeated or chronic everyday life stressors. Above

this, we were bound to couples between the ages of 20 and 45 years because of hormonal changes in men and women after this age. By tendency, older couples in our study expressed less intimacy than younger couples (which is in line with earlier research from (75)). Thus, studies focusing on older couples—or on adolescents in comparison—confronted with external stress would be informative.

Above this, the study setup with the three different conditions would allow for direct comparisons between men and women in a subset of the sample (group 3) only. In this condition, both partners were stressed, which limits the generalization to general sex differences and nonstress situations.

CONCLUSIONS

Our findings support an important role of intimacy on stress buffering and accelerated recovery from stress. Whereas women showed decreased stress reactivity to their partner's intimacy behavior, in both sexes, the partner's intimacy behavior accelerated cortisol recovery from stress. Both men and women expressed spontaneous intimacy behavior before and after stress. The data extend previous findings that partners use touch and physical proximity to help each other regulate stress and show the effects of such behavior on a psychobiological level with impact for individual health. With intimacy being a central element of romantic relationships, we thus identify one mechanism that may explain how couple relationships improve individual health and longevity.

The authors thank the Swiss National Science Foundation for funding (SNSF 100014-115948; 100014-129627). The authors also thank master's students Sophie Wick, Andrea Bender, Carina Benz, Rahel Lutz, Christina Götz, Tina Subiaz, Debora Verciglio, Reto Koch, Luise Deiters, and Flavia Barth for their assistance and effort in the performance of the study.

Source of Funding and Conflicts of Interest: This study was funded by the Swiss National Science Foundation (SNF) Nr. 100013-115948/1 (G.B., M.H., T.N.B.). The authors report no conflicts of interest.

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