Western Journal of Communication

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/rwjc20

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To cite this article: Lisa J. van Raalte & Kory Floyd (2020): Daily Hugging Predicts Lower Levels of Two Proinflammatory Cytokines, Western Journal of Communication, DOI: 10.1080/10570314.2020.1850851

To link to this article: https://doi.org/10.1080/10570314.2020.1850851

Published online: 25 Nov 2020.

Western Journal of Communication
Vol. 00, No. 00, 2020, pp. 1–20

Daily Hugging Predicts Lower Levels of Two Proinflammatory Cytokines

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*The current study asked a sample (*N = *20) of healthy young adults to report their daily hugging behaviors over a 14-day period and to collect their saliva at the beginning and end of the study. Based on affection exchange theory, we hypothesized that the frequency of hugging would be inversely related to proinflammatory cytokines, including interleukins (IL) 1-β, 6, and 8, and tumor necrosis factor-alpha (TNF-α). Controlling for baseline levels, hugging was significantly and inversely related to IL1-β and TNF-α after the 14-day period. Associations with IL-6 and IL-8, although non-significant, were also in the hypothesized direction.*

Keywords: Affection; Cytokines; Health; Hugging; Inflammation

As a highly social species, humans crave social connection. Maslow's (1958) theory of human motivation—commonly referred to as his *hierarchy of needs*—posits that after people fulfill their basic physiological and safety needs, they are motivated to achieve interpersonal belongingness in their social and personal relationships. According to Maslow's theory, failure to attain an adequate level of intimacy with others renders people susceptible to social anxiety, depression, and loneliness. The importance of belongingness is also reflected in Schutz's (1958) fundamental interpersonal relations orientation (FIRO) theory, which explains that social interactions are motivated by fundamental needs for inclusion, affection, and control. The need for inclusion is the need to belong and to be recognized as part of a relationship or group, whereas the need for affection is the need to be loved and to experience interpersonal warmth. Baumeister and Leary's (1995) "need to belong" concept later capitalized on Schutz's need for inclusion and Maslow's belongingness needs by referring to the need to belong as essential for healthy human functioning. Similarly, Floyd's (2019) affection exchange theory expanded on Schutz's need for affection (and, by extension, Maslow's belongingness needs) by claiming that the ability and tendency to communicate affection are evolutionarily adaptive. It is therefore

ISSN 1057-0314 (print)/ISSN 1745-1027 (online)
DOI: 10.1080/10570314.2020.1850851

unsurprising that people thrive mentally, physically, and relationally when their needs for social inclusion are met (Hartung, Sproesser, & Renner, 2015), yet suffer when such needs are thwarted (Baumeister, Brewer, Tice, & Twenge, 2007; Floyd, 2014, 2016).

A principal communication behavior that supports social inclusion needs by facilitating the formation, maintenance, and satisfaction of close relationships is the expression of affection. As described by Floyd and Morman (1998), affectionate communication encompasses those verbal and nonverbal behaviors through which sentiments of love, fondness, closeness, and care are encoded and decoded. Multiple investigations have demonstrated how the communication of affection supports positive qualities in personal relationships, including relational satisfaction (Punyanunt-Carter, 2004), life satisfaction (Curran & Yoshimura, 2016), relationship maintenance (Pauley, Hesse, & Mikkelson, 2014), commitment (Mansson, 2013), and sexual satisfaction (Muise, Giang, & Impett, 2014).

Beyond these relational benefits, however, a substantial empirical literature has identified a variety of ways in which affectionate communication benefits individual health and well-being (Floyd, 2006; Floyd et al., 2018; for an extensive review, see Floyd, 2019). In particular, much of the research grounded in affection exchange theory has found that affectionate communication has stress-ameliorating qualities (Floyd et al., 2007a; Floyd & Riforgiate, 2008), which is potentially clinically significant given the range and magnitude of pathologies that are exacerbated by stress (e.g., Dhabhar, 2014). In the present study, we extend this work to an as-yet uninvestigated correlate of stress: inflammation.

We begin this review by discussing connections between affectionate communication and health from the framework of affection exchange theory (Floyd, 2019). That discussion then focuses more specifically on the health benefits of affectionate touch, and of hugging, in particular. We then describe the nature and measurement of inflammation before hypothesizing that the frequency of daily hugging is inversely associated with physiological inflammatory markers in healthy young adults.

Affectionate Communication and Health

Floyd's affection exchange theory (AET: Floyd, 2019) claims that both giving and receiving expressions of affection are associated with health benefits, at least when the affectionate communication occurs within what Floyd calls the *range of tolerance*, meaning it is not unwanted (van Raalte, Floyd, Kloeber, & Veluscek, 2020) or considered a negative violation of expectations. Multiple studies have confirmed this hypothesis with respect to mental health. For instance, expressed affectionate communication has been linked to greater general subjective wellness (Debrot, Schoebi, Perrez, & Horn, 2013); higher self-esteem (Floyd et al., 2005; Scott, Scott, & McCabe, 1991); and lower alexithymia (Hesse & Floyd, 2008); as well as to a lower likelihood of being diagnosed with generalized anxiety disorder (Floyd, 2014). Similarly, received affectionate communication has been linked to lower anxiety

(Maselko, Kubzansky, Lipsitt, & Buka, 2011); lower depression (Jorm, Dear, Rodgers, & Christensen, 2003); lower stress (Burleson, Trevathan, & Todd, 2007; Coan, Schaefer, & Davidson, 2006); and lower loneliness (Green & Wildermuth, 1993; Mansson, 2014); as well as to a lower likelihood of being diagnosed with major depressive disorder (Kerver, van Son, & de Groot, 1992).

In addition, several cross-sectional and experimental investigations have illuminated the physical health correlates and outcomes of affectionate communication. Much of this research has focused on how the body manages stress. For instance, trait affection level—which indexes an individual's typical or trait-like tendency to express affection to others—is positively related to 24-hour variation in the stress hormone cortisol (Floyd & Riforgiate, 2008), and inversely related to resting heart rate (Floyd et al., 2007b), resting blood pressure, and blood glucose (Floyd, Hesse, & Haynes, 2007), all of which reflect one's physical stress load. Moreover, affectionate communication in close relationships modulates cortisol reactivity to a laboratory stressor (Floyd et al., 2007b; see also Ditzen et al., 2007), and enacting affectionate communication after a stressor accelerates cortisol recovery (Floyd et al., 2007a). Floyd, Pauley, and Hesse (2010) showed that serum oxytocin is partly responsible for the stress-buffering effect of affectionate communication, and additional studies have connected affectionate communication to blood lipids (Floyd et al., 2009; Floyd, Mikkelson, Hesse, & Pauley, 2007); natural killer cell toxicity (Floyd et al., 2014); B cells, T cells, and immunoglobulins (Floyd, Ray, van Raalte, Stein, & Generous, 2018); disordered sleep (Floyd, 2016); and susceptibility to pain (Floyd, Generous, Clark, McLeod, & Simon, 2017).

As Floyd (2019) explained, among all possible forms of affectionate communication, touch seems to have the strongest implications for wellness. Subsequently, we detail research on the benefits of affectionate touch, and then discuss the effects of hugging specifically, which was the focus of this investigation.

Health Effects of Affectionate Touch

Affectionate touch can come in many forms, including hugging, handholding, kissing, cuddling, massaging, and caressing. When these behaviors are communicated in a welcome and appropriate context, they can produce significant health advantages. For example, increased passionate kissing between romantic partners has been connected to lower total serum cholesterol scores (Floyd et al., 2009). Additionally, women who received a ten-minute neck and shoulder massages from their spouse before a laboratory stressor had significantly lower cortisol and heart rate levels compared to those who received verbal social support or no partner interaction (Ditzen et al., 2007).

Even affectionate touch that is less intimate, such as handholding, can have stress-ameliorating effects. For example, women who were threatened with mild electric shock had significantly attenuated neural responses to threats (as measured by functional magnetic response imaging) when holding hands with a stranger or

a spouse than when not holding hands with anyone (Coan et al., 2006). Moreover, for cataract patients, holding hands with a researcher during a 15-minute operation resulted in significantly less self-reported anxiety and epinephrine than not holding hands (Moon & Cho, 2001). Other research has focused specifically on the affectionate communication of hugging, reviewed next.

Specific Effects of Hugging

In one of the first experimental investigation of the health effects of hugging, Clipman (1999) assigned undergraduates to treatment and comparison conditions for a four-week trial. After completing a measure of subjective well-being, participants in the treatment group were instructed either to give or receive at least five hugs per day, whereas those in the comparison group recorded the number of hours they spent reading each day. Subsequent to the intervention, participants reported on their well-being again. Clipman predicted that hugging would significantly increase well-being.

As hypothesized, treatment participants reported a significant increase in wellness over the course of the four-week intervention, whereas wellness scores for controls did not change. Neither the average number of daily hugs exchanged, nor the average number of different people hugged per day, were influential.

Although promising, the Clipman study did not prescreen participants for conditions that might otherwise have affected their wellness and relied on a report of subjective well-being rather than an objective assessment of wellness. The risk of demand characteristics was high (see, Nichols & Maner, 2010). Later investigations, however, have demonstrated that hugging is associated with objectively measured health indicators, in support of Clipman's general thesis. For instance, Light, Grewen, and Amico (2005) found that the frequency of spousal hugging was associated with lower blood pressure and higher circulating oxytocin in premenopausal women.

In a notable study, Cohen, Janicki-Deverts, Turner, and Doyle (2015) recruited a sample of 404 healthy adults. On each of 14 consecutive days, the researchers measured whether participants had been hugged that day. Participants were then quarantined and exposed either to a rhinovirus or an influenza virus. They remained in quarantine for either five days (rhinovirus group) or six days (influenza virus group), during which time their nasal secretions, daily mucus weights, and nasal clearance time were measured daily, to determine whether participants had been infected by cold-like symptoms. Nasal secretions were then cultured for evidence of viral infection.

Cohen and colleagues found that the percentage of days on which participants had received a hug was inversely associated with the risk of infection (odds ratio = 0.39). More specifically, higher rates of daily hugging predicted more efficient nasal clearance, although rates of hugging were unrelated to mucus production. The researchers also reported that for infrequently hugged participants, daily tension was associated with elevated infection risk, but not for frequently hugged

participants, suggesting a stress-buffering effect of hugging (see Cohen & Wills, 1985; see also Murphy, Janicki-Deverts, & Cohen, 2018).

The Cohen et al. experiment was notable in its demonstration that hugging had an immuno-protective effect, buffering individuals against the risk of viral infection. One limitation of the design, however, was that the measure of hugging enumerated only the percentage of days on which participants had received a hug, instead of enumerating the *number of hugs* shared each day. It is thus impossible to know whether receiving, say, five or ten hugs per day is more immuno-protective than receiving only one.

The collective implication of this research is that affectionate touch—including hugging, specifically—is associated with both self-reported and objectively measured markers of health, particularly those markers related to stress and immunocompetence. A potentially relevant outcome not yet adjudicated in the research on affectionate touch is inflammation, despite the fact that it is a common physical symptom of many correlates of affection, including anxiety (Vogelzangs, Beekman, De Jonge, & Penninx, 2013), depression (Miller & Raison, 2016), and disordered sleep (Simpson & Dinges, 2007). In the subsequent section, we describe inflammation and inflammatory markers, and offer specific hypotheses about their connection with affectionate touch.

Inflammation

Inflammation is an innate immune response to infection, whereby eicosanoids (molecules made up of 20-carbon polyunsaturated fatty acids) and cytokines (cell-signaling molecules) produce symptoms such as fever, redness, pain, and swelling, which are associated with attacking viral and bacterial pathogens (see Abbas, Lichtman, & Pillai, 2020). Like stress, inflammation has different effects when acute than when chronic. Acute inflammation signals the immune system to heal and repair damaged tissue and to defend against pathogenic attacks, which are adaptive, health-maintaining responses. Chronic inflammation, however, produces deleterious effects that pose a substantial morbidity and mortality risk. This is largely due to the prevalence of chronic inflammation in a range of pathologies, including chronic respiratory diseases, multiple sclerosis, cancer, obesity, allergies, diabetes, rheumatoid arthritis, and chronic obstructive pulmonary disease (COPD) (see Barcelos, Troxell, & Graves, 2019; Wellen & Hotamisligil, 2005). The epidemiology and risk factors of these pathologies vary. COPD, for instance, is estimated to affect 4.8 million U.S. adults, particularly those who smoke, suffer from asthma, or are exposed to air pollution (Mannino, 2002). More than one in five U.S. adults is obese, and 7.9% are diabetic, both conditions for which inactivity and family history are primary risk factors (Mokdad et al., 2003). Worldwide, chronic inflammatory diseases are responsible for nearly 60% of deaths (Pahwa, Goyal, Bansal, & Jialal, 2020).

One strategy for assessing chronic inflammation is to measure the levels of proinflammatory cytokines (Maes et al., 1998). These include, among others,

interleukins 1-β, 6, and 8, and the cell signaling protein tumor necrosis factor-alpha (TNF-α) (Koelman, Pivovarova-Ramich, Pfeiffer, Grune, & Aleksandrova, 2019). For all of these markers, higher values index elevated inflammation.

According to AET, one of the primary pathways through which affectionate communication influences health is modulation of the stress response, and research has shown that affectionate communication covaries with chronic stress (Floyd, 2006), buffers individuals against the effects of acute stressors (Floyd et al., 2010), and accelerates cortisol recovery after stress-induced elevation (Floyd et al., 2007a). Multiple other studies have linked stress, both acute (Steptoe, Hamer, & Chida, 2007) and chronic (Kiecolt-Glaser et al., 2003), to elevated proinflammatory cytokine levels (IL-6 and 1-β, specifically). We contend that it logically follows that affectionate communication has an inhibitory effect on cytokine levels, which would result in inverse associations between those levels and enacted affectionate communication.

In this study, we examine that prediction in the context of interpersonal hugging. Our specific hypotheses are as follows:

H1: Controlling for baseline values, daily hugging is inversely related to IL1-β.
H2: Controlling for baseline values, daily hugging is inversely related to IL-6.
H3: Controlling for baseline values, daily hugging is inversely related to IL-8.
H4: Controlling for baseline values, daily hugging is inversely related to TNF-α.

Method

Participants and Recruitment

Participants (N = 20) were 12 women and 8 men who ranged in age from 18 to 30 years (M = 20.55 years, SD = 2.82). Participants self-identified as Caucasian (9), African American (5), Hispanic (2), Asian (2), or as having another ethnic background (1; one did not respond). Most (14) identified as heterosexual, whereas three identified as homosexual and three as bisexual.

Participants were recruited from among the undergraduate student population at a moderately sized university in the southern United States. Prospective participants completed online prescreening assessments. Prospective participants were considered unqualified for the study if they reported 1) any history of diagnosis or treatment for hypotension, hepatitis, endocrine disease, kidney or liver disease, cancer, cardiovascular disease, diabetes, rheumatological disorders, respiratory problems, sleeping disorders, gingivitis or periodontal disease, autism spectrum disorders and/or fibromyalgia; 2) any history of chemotherapy or chest radiation; 3) current use of tobacco; or 4) current use of alpha blockers, beta blockers, steroids, or sleeping aids (prescription or over-the-counter). Female participants who were breastfeeding were also excluded from the study. These exclusion criteria were enforced because they can affect the accuracy of salivary analyses.

Procedure

All study procedures were IRB-approved. All qualified participants were invited to a communication laboratory for their first lab visit which took approximately twenty-five minutes. During this first visit, participants were provided with the study information and consent form. After signing their consent, assessment of body mass index (BMI), pulse rate and oxygen saturation (SpO^2) with a finger pulse oximeter, and systolic and diastolic blood pressure by a manual sphygmomanometer were collected. Average baseline values were normal for pulse rate, oxygen saturation, and blood pressure, and average BMI corresponded to a slightly overweight body; specific values appear in Table 1.

Participants were then provided with a simulated demonstration for their saliva collections that they would be conducting at home. Saliva was collected via a passive drool procedure using Saliva Collection Aids (SCA; Salimetrics, State College, PA). To do this, participants were instructed to place the SCA into a pre-labeled vial and to allow their saliva to pool in their mouth and guide the saliva into the vial. After 2 mL were collected, participants were instructed to remove and discard the SCA and attached a cap to the collection vial. Immediately after collecting their saliva, participants stored their samples in their own freezer and then returned the samples on the following day to the communication laboratory, where they were stored in an ultra-low freezer set at −80°C.

Participants collected their saliva at two time points during the study: immediately before (Time 1) and immediately after (Time 2) the 14-day protocol. At each time point, participants collected four saliva samples over the course of the day: upon awakening, 30 minutes post-awakening, before lunch, and before dinner. Each of the four saliva collections used a new SCA and labeled vial. Participants were instructed not to brush their teeth or eat or drink anything except water for at least 30 minutes prior to each saliva collection. In addition to the in-person lab demonstration for the saliva collections, participants were provided an instructional sheet to take home with them that replicated the instructions. Participants were told to contact the researcher if they had any concerns or questions during their collection period (no participants contacted the researcher with questions).

Table 1 *Baseline Vital Signs* ($N = 20$)

Model	Min	Max	*M*	*SD*
Pulse rate	50.00	108.00	82.70	14.70
SpO^2	74.00	99.00	96.55	5.41
Systolic blood pressure	110.00	140.00	119.40	7.84
Diastolic blood pressure	70.00	88.00	76.45	5.32
Body mass index	19.05	41.52	26.32	4.75

Notes. Pulse rate was measured in beats per minute. SpO^2 is measured as the percentage of oxygenated hemoglobin relative to total hemoglobin. Systolic and diastolic blood pressure are measured in millimeters of mercury (mm Hg). Body mass is calculated as kg/m^2.

After participants returned their Time 1 saliva collections, they received a 14-day paper daily diary form to complete at the end of each day. Participants returned their daily diary packet and Time 2 saliva collections at the end of the study and were debriefed in the communication laboratory. Samples were shipped on dry ice to the Salimetrics SalivaLab. Participants were provided two installments adding up to a 25 USD Target gift card, once after they returned their first saliva collection, and again at the end of the study.

Measures

Assessment of Daily Hugging

Participants were instructed to complete a section of the paper daily diary form at the end of each day during the 14-day protocol. For each day, participants were asked to report how many hugs they had received that day. To avoid calling attention to hugging, specifically, we embedded the hugging item among filler items, including asking about the number of times participants logged onto social media, talked on the phone, and argued with someone.

Proinflammatory Cytokine Tests

Saliva samples were tested (assayed) for the Salimetrics Cytokine Panel (IL-1β, IL-6, TNF-α, and IL-8) in duplicate (for computing reliability) at the Salimetrics SalivaLab (Carlsbad, CA) using a proprietary electrochemilluminesence method developed and validated for saliva by Salimetrics. The 30 minutes post-awakening sample was used for the cytokine assays, as advised by Salimetrics. The average coefficient of variation for all samples tested was <15%, which meets the SalivaLab's criteria for accuracy and repeatability in Salivary Bioscience and exceeds the applicable NIH guidelines for Enhancing Reproducibility through Rigor and Transparency. Sample test volume was 25 μL (microliter) of saliva per determination. The assay has a lower limit of sensitivity of 0.0314 pg/mL (TNF-α), 0.0195 pg/mL (IL-1β), 0.0491 pg/mL (IL-6), and 0.0201 pg/mL (IL-8), with a dynamic range from 0.0314–380 pg/mL (TNF-α), 0.0195–589 pg/mL (IL-1β), 0.0491–736 pg/mL (IL-6), and 0.0201–574 pg/mL (IL-8). Prior to testing, samples were stored at −80°C before being shipped on dry ice to the Salimetrics SalivaLab.

Glucocorticoid Assays

Proinflammatory cytokine levels can be affected by glucocorticoids such as cortisol (Elenkov & Chrousos, 2002). To examine their potential effects, we also analyzed the samples for the glucocorticoid cortisol. Saliva samples were assayed at the Salimetrics SalivaLab using Salimetrics Salivary Cortisol Assay Kit (Cat. No. 1–3002), without modifications to the manufacturers' protocol. Samples were thawed to room temperature, vortexed, and then centrifuged for 15 minutes at approximately 3,000 RPM (1,500 x g) immediately before performing the assays. Samples were tested for

salivary cortisol using a high sensitivity enzyme immunoassay. Sample test volume was 25 μl of saliva per determination. The assay has a lower limit sensitivity of 0.007 μg/dL, a standard curve range from 0.012–3.0 μg/dL, an average intra-assay coefficient of variation of 4.60%, and an average inter-assay coefficient of variation of 6.00%, which meets the manufacturer's criteria for accuracy and repeatability in salivary bioscience and exceeds the applicable NIH guidelines for Enhancing Reproducibility through Rigor and Transparency.

Results

Descriptive Analyses

We created a total hugging score by summing participants' daily counts of their number of hugs during the 14 days of the study. Women reported more hugs (M = 42.92, SD = 39.00) than did men (M = 22.63, SD = 8.23), but the difference was not statistically significant, $t(18) = -1.44$, p(2-tailed) =.17, d = .72. Number of hugs was not significantly correlated with age, $r(18) = -.30$, p = .19.

Participants also reported as part of the daily diary how good and how typical each day was, on a scale of 1 (*not at all*) to 7 (*very*). We created averaged versions of each variable, where each had a theoretic range of 1 to 7. Women reported slightly higher goodness of their days (M = 5.32, SD = 0.93) than did men (M = 5.10, SD = 0.91), but the difference was not statistically significant, $t(18) = -.53$, p = .60, d = .24. Goodness was not significantly correlated with age, $r(18)$ = .24, p = .315. Women reported slightly higher typicality of their days (M = 4.68, SD = 1.33) than did men (M = 4.55, SD = 0.96), but the difference was not statistically significant, $t(18) = -.25$, p = .81, d = .12. Typicality was not significantly correlated with age, $r(18) = -.04$, p = .868.

To consider goodness and typicality as potential control variables, we correlated each variable with time-2 cytokine values. Goodness was significantly correlated with time-2 TNF-α, $r(18) = -.48$, p = .031, so it was used as a control variable in the test of Hypothesis 4. Typicality was not correlated with any of the time-2 cytokines at a bivariate level, so we did not use it as a control variable. We also considered sex and age as potential control variables, but there were no significant sex differences and no significant correlations with age for any of the time-2 cytokines.

Finally, to consider cortisol as a potential control variable, we correlated the time-2 cytokine values with time-2 waking cortisol, the cortisol awakening response (calculated as the 30-minute post-awakening value minus the awakening value), and the total variance of the cortisol curve (calculated as a linear orthogonal polynomial; see Pennebaker, Mayne, & Francis, 1997). All associations were non-significant for all four cytokines, so cortisol was not used as a control variable in the hypothesis tests. Table 2 presents minimum and maximum values, means, standard deviations, and intercorrelations for all study variables.

Hypothesis Tests

To test the hypotheses, we used hierarchical multiple regressions to examine the effects of daily hugging on time-2 cytokines. All cytokine values in the regressions were log-10 transformed.

For IL1-β, the regression included time-1 IL1-β in the first step and summed hugs in the second step. With the effects of time-1 IL1-β controlled, summed hugs negatively predicted time-2 IL1-β, $\beta = -.29$, $p = .04$. Full regression results appear in Table 3. The first hypothesis is confirmed.

For IL-6, the regression included time-1 IL-6 in the first step and summed hugs in the second step. With the effects of time-1 IL-6 controlled, summed hugs did not significantly predict time-2 IL-6, $\beta = -.22$, $p = .14$, even though the result was in the predicted direction. Full regression results appear in Table 4. The second hypothesis is not confirmed.

For IL-8, the regression included time-1 IL-8 in the first step and summed hugs in the second step. With the effects of time-1 IL-8 controlled, summed hugs did not significantly predict time-2 IL-8, $\beta = -.19$, $p = .14$, even though the result was in the predicted direction. Full regression results appear in Table 5. The third hypothesis is not confirmed.

For TNF-α, the regression included time-1 TNF-α and summed goodness in the first step, and summed hugs in the second step. With the effects of time-1 TNF-α and summed goodness controlled, summed hugs negatively predicted time-2 TNF-α, $\beta = -.32$, $p = .02$. Full regression results appear in Table 6. The fourth hypothesis is confirmed.

Discussion

Affection exchange theory proposes that, at least in the absence of mitigating factors, affectionate interpersonal behavior is associated with stress-ameliorating and immuno-supportive health benefits (Floyd, 2019). Multiple investigations have demonstrated this hypothesized effect for various affectionate communication behaviors (Coan et al., 2006; Floyd et al., 2009), including hugging (Cohen et al., 2015; Light et al., 2005). On that theoretic basis, we hypothesized that the frequency of daily hugging would predict lower markers of inflammation, net of the prediction power of baseline inflammation levels. Our prediction was supported for the proinflammatory cytokines IL1-β and TNF-α, and although the prediction power for IL-6 and IL-8 were not statistically significant, they were in the hypothesized direction and produced nontrivial effect sizes, suggesting that they may have emerged as significant with a larger sample.

Inflammation is a clinically significant health marker, insofar as chronic inflammation is instrumental in a range of pathologies, both physical and mental. That includes stress (Cohen et al., 2012), which AET proposes can be buffered by positive affectionate communication. Whereas other studies have demonstrated that expressions of affection predict lower stress (at least, physiologically), this was the first

Table 2 *Descriptive Statistics and Intercorrelations for Study Variables* ($N = 20$)

Variable	Min	Max	*M*	*SD*	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Daily hugging (14-day sum)	5.00	157.00	34.80	31.77	–												
2. IL1-β Time 1	27.23	914.82	280.84	265.63	.25	–											
3. IL1-β Time 2	15.35	1084.34	169.08	238.94	−.08	.75†	–										
4. IL-6 Time 1	.68	9.56	2.97	2.11	.45*	.60†	.59†	–									
5. IL-6 Time 2	.41	7.09	2.28	1.75	.11	.56*	.63†	.65†	–								
6. IL-8 Time 1	202.43	4486.80	1212.98	1125.54	.51*	.74†	.54*	.71†	.42	–							
7. IL-8 Time 2	76.82	2271.17	697.03	575.11	.26	.67†	.78†	.54*	.54*	.78†	–						
8. TNF-α Time 1	.75	11.72	3.54	2.89	.47*	.80†	.59†	.75†	.47*	.90†	.78†	–					
9. TNF-α Time 2	.34	9.54	2.39	2.16	.13	.57†	.78†	.57†	.53*	.67†	.90†	.70†	–				
10. Goodness (14-day mean)	2.36	6.36	4.63	1.17	−.13	−.01	−.29	−.25	−.23	−.22	−.37	−.10	−.53*	–			
11. Typicality (14-day mean)	3.57	6.43	5.23	0.90	.02	.11	.03	−.16	.11	−.15	−.02	−.03	−.17	.48*	–		
12. Day-15 awakening cort	0.04	0.69	0.31	0.20	−.33	−.09	−.05	−.23	−.04	−.13	−.02	−.21	−.11	.19	−.14	–	
13. Day-15 cort awakening response	−0.43	0.51	0.07	0.24	−.20	−.10	−.12	−.51	−.15	−.42	−.25	−.34	−.26	.50	.52	.31	
14. Day-15 cort curve	−2.37	0.59	−0.85	0.78	.36	−.05	−.02	.22	.08	.04	.08	.16	.18	−.25	.04	−.84†	−.30

Notes. *$p < .05$; †$p < .01$. Probability values are two-tailed. Raw (untransformed) versions of cytokine and cortisol measures are reported for high and low values, means, and standard deviations. Log-10 transformed versions of cytokine and cortisol measures are used for intercorrelations. Raw cytokine values are expressed in pg/mL. Raw cortisol values are expressed in μg/dL.

Table 3 *Multiple Regression Predicting IL1-β from Daily Hugging* (N = 20)

Model	Variables	Zero-order *r*	B	SE B	β	ΔR^2
1	Baseline IL1-β	.75*	.69	.14	.75*	.56*
2	Baseline IL1-β	.75*	.75	.14	.82*	.08*
	Daily hugging	−.08	−.004	.002	−.29*	

Notes. R^2 =.64, adjusted R^2 =.60, F (2, 17) = 15.13, p <.001. *p <.05.

Table 4 *Multiple Regression Predicting IL-6 from Daily Hugging* (N = 20)

Model	Variables	Zero-order *r*	B	SE B	β	ΔR^2
1	Baseline IL-6	.65*	.72	.20	.65*	.42*
2	Baseline IL-6	.65*	.82	.22	.75*	.04
	Daily hugging	.11	−.002	.002	−.22	

Notes. R^2 =.46, adjusted R^2 =.40, F (2, 17) = 7.33, p <.005. *p <.05.

Table 5 *Multiple Regression Predicting IL-8 from Daily Hugging* (N = 20)

Model	Variables	Zero-order *r*	B	SE B	β	ΔR^2
1	Baseline IL-8	.78*	.85	.16	.78*	.61*
2	Baseline IL-8	.78*	.96	.19	.88*	.03
	Daily hugging	.26	−.003	.002	−.19	

Notes. R^2 =.64, adjusted R^2 =.59, F (2, 17) = 14.91, p <.001. *p <.05.

Table 6 *Multiple Regression Predicting TNF-α from Daily Hugging* (N = 20)

Model	Variables	Zero-order *r*	B	SE B	β	ΔR^2
1	Baseline TNF-α	.70*	.73	.15	.65*	.70*
	Daily goodness	−.57*	−.21	.06	−.46*	
2	Baseline TNF-α	.70*	.90	.15	.80*	.08*
	Daily goodness	−.57*	−.22	.06	−.49*	
	Daily hugging	.13	−.004	.002	−.31*	

Notes. R^2 =.78, adjusted R^2 =.73, F (3, 16) = 18.41, p <.001. *p <.05.

study of which we are aware to link affectionate communication to lower inflammation.

In addition to supporting a principal prediction of AET, these findings contribute to a robust and growing literature on the centrality of affectionate communication to the human condition. Floyd has long argued that affectionate communication is a fundamental human need—and that although there is substantial individual variation in how frequently or intensely people need affection, few if any people need none (see Floyd, 2019). That argument is premised on AET's claim that the propensity for

affectionate communication evolved in the human species due to its contributions to viability and fertility, and that affectionate communication exerts at least some of its benefit via pathways that regulate stress, immunocompetence, and reward.

As Floyd (2019) details, evidence for the benefit of hugging has supported speculation about its use as a therapeutic intervention. For instance, L'abate's (2008) intervention for supporting relational intimacy—dubbed 3HC (for hugging, holding, huddling, and cuddling)—prescribes a progressive touch exercise for romantic partners to increase relationship satisfaction. Quinnett (2009) also describes a hugging-based therapeutic practice for counseling suicidal individuals, one aimed at reinforcing social and relational inclusion. Similar interventions have surfaced in the nonclinical realm as well, including Buddhist hugging meditation (Hahn, 2000), pajamas that simulate hugging between a parent and child (Teh et al., 2008), and the practice of cuddle parties (Cross, 2006). Virtually no empirical research attests to the efficacy of any of these interventions, however, so hugging interventions remain a potentially fruitful avenue for further study.

An important caveat about the present findings is that they do not imply that hugging is beneficial—or equally beneficial—to everyone. For instance, children on the autism spectrum or with Asperger syndrome or alexithymia may find tactile affectionate communication intrusive and stress inducing (Andrews, Attwood, & Sofronoff, 2013; Sofronoff, Eloff, Sheffield, & Attwood, 2011). Similar observations may be made about survivors of sexual abuse or trauma (see Maltz, 2002). Affectionate touch—and hugging in particular—may also be physically uncomfortable for people with conditions such as fibromyalgia, burns, or inflammatory skin disorders such as dermatitis (Gracely, Grant, & Giesceke, 2003). Finally, people vary in their desire for and comfort with affectionate touch (Floyd, 2019), and those who, for either hereditary or environmental reasons, find an embrace unpleasant may easily react to the behavior with a stress response (Chopik et al., 2014; Rabinowitz, 1991). When considering the health benefits (or any benefits) of affectionate touch, therefore, it is critical to identify these and similar likely exceptions.

We speculate that the failure to identify significant relationships with IL-6 and IL-8 was caused primarily by limited statistical power, given the effect sizes of those relationships. We therefore suggest replication with a larger sample.

Strengths, Limitations, and Future Directions

Like much of the research identifying health benefits of affectionate communication, this study benefited from an objective assessment of inflammatory markers. Whereas one might measure health- or stress-related variables via self-report, the use of objective physiological assessment adds immense credibility to claims of connection between behavior and health, insofar as such assessments are not subject to recall or social desirability biases (Garber, Nau, Erickson, Aikens, & Lawrence, 2004).

A second strength of this study was the use of a longitudinal daily diary to measure hugging frequency. Whereas some hugging studies (e.g., Light et al., 2005) assess hugging behavior via a one-time questionnaire, we modified the strategy employed by Floyd et al. (2010) and asked participants to record their frequency of hugging on a daily basis over a two-week period. We contend that this measurement strategy at least reduced recall bias associated with retrospective reporting.

Although the sample size was small relative to typical interpersonal communication research, it was within the norm for psychophysiological studies (e.g., Marazziti & Canale, 2004; van Niekerk, Huppert, & Herbert, 2001), including those conducted within the communication field (e.g., Tardy, Thompson, & Allen, 1989). A relative lack of measurement error for physiological markers, compared to other operational strategies such as self-report measures and behavioral coding, speaks to the adequacy of smaller sample sizes for identifying significant patterns of covariation, although replication with larger samples will increase confidence in generalizability.

A second limitation of the design was that our assessment was only of the frequency of hugging; we did not attend to any of its important qualities, such as duration, pressure, body position, and relative hand and arm placement, nor to the number of different individuals hugged and the nature of those relationships (Forsell & Åström, 2012). These variables have the potential to influence evaluations of a hug and, by extension, its effects (Floyd, 1999; Hertenstein, Keltner, App, Bulleit, & Jaskolka, 2006). With respect to relationship types, however, it should be noted that affectionate touch is not necessarily beneficial only when enacted in the context of close personal relationships. For instance, Coan et al. (2006) demonstrated that handholding was beneficial even when enacted by a stranger. Thus, although we do not know the nature of the relationships in which the hugs in the present study occurred, we contend that hugging can be health supportive even when enacted with strangers or weak social ties.

Similarly, even as culture affects the occurrence of hugging (Field, 1999; Franco, Fogel, Messinger, & Frazier, 1996), it may also moderate the acceptability of, or preference for, hugging in social interaction, either alone or in combination with biological sex. That variation is potentially important in specifying the conditions under which hugging is most beneficial to health.

Similar to immunocompetence (Farnè, Boni, Corallo, Gnugnoli, & Sacco, 1994), no single measure provides a standard, global assessment of inflammation. The proinflammatory cytokines IL-1β, IL-6, IL-8, and TNF-α are commonly measured, yet other outcomes also index inflammation. In clinical settings, for instance, C-reactive protein (CRP) is often assessed as an inflammatory marker. Although Steptoe et al.'s (2007) meta-analysis showed more robust associations for stress with the proinflammatory cytokines IL-1β and IL-6 than with CRP, the inclusion of additional inflammatory markers in replication studies may be informative.

In conclusion, future research on the link between hugging and inflammation would benefit from taking account of the relational, environmental, and behavioral characteristics of daily hugs, even if only as sources of error variance. We might speculate, for

instance, that a prolonged and intimate hug with a romantic partner or close friend may have greater stress-alleviating effects than a brief social hug with an acquaintance; assessing only the frequency of daily hugging precludes the ability to test that speculation. Going further, if replications of this correlational protocol are successful, they may support efforts to effect reductions in chronic inflammation experimentally, through the manipulation of hugging in designs similar to Floyd et al.'s (2009) manipulation of kissing and van Raalte, Floyd, and Mongeau's (2019) manipulation of cuddling.

Acknowledgments

We would like to acknowledge Taylor Butler and Isabella Vazquez, students at Sam Houston State University, for their help with data collection.

Disclosure Statement

No potential conflict of interest was reported by the authors.

Funding

This study was funded by an Enhanced Research Grant provided by the [Office of Research and Sponsored Programs at Sam Houston State University].

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