

Moderators of the Relationship Between Frequent Family Demands and Inflammation Among Adolescents

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Objective: Frequent demands from others in relationships are associated with worse physiological and health outcomes. The present research investigated 2 potential moderators of the relationship between frequency of demands from one's family and inflammatory profiles among adolescents: (a) closeness of adolescents' relationships with their families, and (b) the frequency with which adolescents provided help to their families. **Method:** Two hundred thirty-four adolescents, ages 13–16 ($M_{\text{age}} = 14.53$; 47.83% male), completed a daily diary in which they reported on the frequency of demands made by family members. They were also interviewed about the closeness of their family relationships and reported in the daily diary on how frequently they provided help to their families. Adolescents also underwent a blood draw to assess low-grade inflammation and proinflammatory cytokine production in response to bacterial stimulation. **Results:** More frequent demands from family predicted higher levels of low-grade inflammation and cytokine production in response to bacterial stimulation in adolescents. Family closeness moderated the relationship between frequent demands and stimulated cytokine production such that more frequent demands predicted higher cytokine production among adolescents who were closer to their families. Furthermore, frequency of providing help moderated the relationship between frequent demands and both low-grade inflammation and stimulated cytokine production, such that more frequent demands predicted worse inflammatory profiles among adolescents who provided more help to their families. **Conclusions:** These findings build on previous work on family demands and health to show under what circumstances family demands might have a physiological cost.

Keywords: demands, helping behavior, close relationships, inflammation

Close relationships with others serve many beneficial purposes, but they may also simultaneously carry burdens. Demands in relationships can take a physiological toll, particularly when they are frequent or persistent (Brooks & Dunkel Schetter, 2011; Weinstein, Goldman, Hedley, Yu-Hsuan, & Seeman, 2003). For example, caring for a seriously ill family member, which often entails multiple, ongoing demands, predicts detrimental physiological outcomes, such as increased inflammation and sympathetic nervous system activity (Rohleder, Marin, Ma, & Miller, 2009; Vitaliano, Zhang, & Scanlan, 2003). Frequent demands from family members are also correlated with higher inflammation among adolescents (Fuligni et al., 2009). The current study extends this work to examine under what conditions frequent demands from one's family are more or less detrimental for adolescents' inflammatory profiles, including low-grade inflammation and cytokine production in response to bacterial stimulation.

Physiological Correlates of Frequent Demands

Relationships with people who make too many demands can have negative health implications (Brooks & Dunkel Schetter, 2011). For example, social strain, an umbrella concept that includes frequent demands, predicts higher levels of inflammation (Yang, Schorpp, & Harris, 2014). In one study that specifically examined demands, elderly adults who reported that people who were close to them made many demands had higher levels of allostatic load, an index of cumulative biological risk (Weinstein et al., 2003). Similarly, caring for a seriously ill family member predicts elevations in sympathetic nervous system activity, low-grade inflammation, and global self-reported health (Rohleder et al., 2009; Vitaliano et al., 2003). In addition, one study of adolescents found that those who helped their families more (e.g., cooking, cleaning, sibling care) had higher levels of soluble interleukin 6 (IL-6) receptor and C-reactive protein (CRP; Fuligni et al., 2009).

When Will Demands From Family Relate to Heightened Inflammatory Profiles?

Although a substantial literature reveals that frequent demands in relationships predict worse physiological outcomes, we suggest that this relationship might depend on characteristics of adolescents' family relationships and of the adolescents themselves. With respect to family relationship characteristics, frequent demands may have different associations with inflammatory profiles depending on how close adolescents are to their families. There are

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two plausible, and competing, hypotheses as to the nature of such an interaction. On one hand, frequent demands might be *less* strongly associated with inflammatory profiles among adolescents with closer family relationships. This pattern would emerge if support from close family members buffered against the stress of demands from the family or if adolescents who are close to their families derived an especially strong sense of role fulfillment out of complying with their families' demands (Cohen & Wills, 1985; Fuligni et al., 2009; Uchino, 2006). On the other hand, literature showing that, in some circumstances, close relationships within families can predict higher levels of inflammation (Manczak, Basu, & Chen, 2016; Manczak, DeLongis, & Chen, 2016) raises the possibility that demands might be *more* detrimental to inflammatory profiles among adolescents who are closer to their families. People who provide care for close others experience a greater sense of burden and of being trapped in their helping role, suggesting that demands within the context of especially close relationships may confer a sense of obligation (Adams, McClendon, & Smyth, 2008; Hughes, Giobbie-Hurder, Weaver, Kubal, & Henderson, 1999; Lawrence, Tennstedt, & Assermann, 1998). Adolescents who feel obligated to meet their families' demands risk focusing on their families' needs to the exclusion of their own needs, which can also be detrimental to health (Nagurney, 2007). Taken together, this literature supports the idea that frequent demands could be associated with detrimental inflammatory profiles among adolescents who are closer to their families.

With respect to individual characteristics of the adolescent, frequent demands may have different relationships with inflammatory profiles depending on how often adolescents are inclined to help their families. Here, we distinguish between demands, which are what family members ask of the adolescent, and help, which is what the adolescent provides to the family. There are also two plausible, and competing, hypotheses as to the nature of this interaction. One is that providing frequent help might mitigate the negative effects of frequent demands. Adolescents who are able to provide help to a family that needs it (i.e., that makes frequent demands) might derive a greater sense of meaning, purpose, or role fulfillment from their actions, which could be physiologically beneficial (Bower, Kemeny, Taylor, & Fahey, 2003; Fuligni et al., 2009). Conversely, adolescents who have frequent demands made by their families but do not provide frequent help might realize that they are letting their families down (Wells & Jones, 2000), which could, in turn, create experiences of stress that would be detrimental to their inflammatory profiles. The alternative hypothesis, however, is that demands will be associated with worse inflammatory profiles among adolescents who do help their families frequently. This hypothesis is based on the notion that adolescents who have a lot of demands made and who provide a great deal of help may be doing so because they feel a sense of obligation, and that this obligation leads them to help their families at the expense of other activities, such as schoolwork, sleep, or socialization (East, Weisner, & Reyes, 2006; Fuligni & Hardway, 2006; Fuligni, Yip, & Tseng, 2002). The resulting loss of their own personal time could be detrimental physiologically. Conversely, the freedom to choose to provide help to others in the absence of demands could allow the physiological benefits of helping to emerge (Schreier, Schonert-Reichl, & Chen, 2013).

Study Overview

This study examined how the frequency of demands from family members related to adolescents' inflammatory profiles. Demands were assessed by having adolescents rate whether family members made demands each day for two weeks. Inflammatory profiles were assessed by measuring (a) low-grade inflammation, a composite of basal IL-6 and CRP, and (b) proinflammatory cytokine production in response to bacterial stimulation. The latter was a composite of the levels of interleukin 1 beta (IL-1 β), IL-6, interleukin 8 (IL-8), interleukin 10 (IL-10), and tumor necrosis factor alpha (TNF- α) produced after blood was exposed *in vitro* to lipopolysaccharide (LPS). Consistent with past research, we first tested and hypothesized a main effect, whereby adolescents who reported more frequent family demands would have worse inflammatory profiles. In addition, we tested the interaction of family demands with both relationship closeness and with adolescent helping behaviors in predicting adolescent inflammatory profiles. Because two competing hypotheses were being tested with these moderator analyses, we did not make specific directional hypotheses.

Method

Participants

Participants were adolescents who participated in a larger study on psychosocial factors and health in families. Two hundred sixty-one families were recruited through public schools, newspaper advertisements, and community postings. The participants in the present analyses included the children of this sample. Of the original 261, 234 completed the daily diary measures that included the measure of frequency of demands from one's family, and thus the present analyses are based on these 234 participants. Of these participants, 47.83% were boys, and their mean age was 14.53 ($SD = 1.06$). In terms of race/ethnicity, 50.0% were of European descent, 16.7% were of Chinese descent, 7.3% were of Indian descent, 13.2% were of other Asian descent, 4.3% were of African descent, 4.3% were of Latin American/Hispanic descent, 3.4% were of Aboriginal/First Nations descent, and 0.9% were of other racial/ethnic descent. In addition, on a scale where 1 = *less than a high school diploma*, 2 = *high school diploma*, 3 = *some college*, 4 = *BA*, and 5 = *graduate school*, parents' mean level of education was 3.82 ($SD = .89$), with 64.1% having at least a bachelor's degree. Participants were healthy 13–16-year-olds, with no history of chronic medical or psychiatric disorders, and no acute illness within the past two weeks. Adolescents visited the lab, where they were interviewed about their family relationships and underwent a blood draw. In addition, adolescents completed a daily diary for two weeks following the lab visit. The research was approved by the University of British Columbia Institutional Review Board (IRB). Parents provided written consent, and children provided written assent for participation.

Psychosocial Variables

Frequency of demands from family. For 14 days following the laboratory visit, adolescents completed daily diaries, either online or on paper. Those completing the daily diaries on paper

were provided with an electronic stamper with which they were asked to stamp each diary entry when they completed it. The stamper recorded the date and time and could not be reset without a password. Each day, adolescents answered a number of questions about their day. Of relevance to this paper was the item, "Today, I had a lot of demands made by family." This prompt was answered in a yes/no format by the adolescent each day. A demand frequency score was computed by dividing the number of days yes was selected by the total number of days the daily diary was completed. 89.66% of adolescents completed the daily diary. The mean number of days completed was 10.84 ($SD = 4.22$).

Family closeness. Adolescents' relationships with their families were assessed using the family section of the UCLA Life Stress Interview (Hammen, 1991). This semistructured interview provides an assessment of chronic stress across multiple domains of life over the previous 6 months. In the family domain, trained interviewers probe the quality of relationships that children have with their immediate family members in terms of closeness, trust, openness, conflict, and support. A single rating is made by the interviewer, ranging from 1 (*exceptional quality of relationship with all family members*) to 5 (*poor quality relationships with family members and significant problems*), pervasive across family members (interclass coefficients = .87–.96). For the purposes of this study, we refer to this variable as family closeness, and scores were reverse coded so that higher number scores indicate closer family relationships. This interview has been used successfully with adolescents (Chen, Fisher, Bacharier, & Strunk, 2003; Marin, Chen, Munch, & Miller, 2009; Murphy, Slavich, Chen, & Miller, 2015) and has high reliability and validity (Hammen, 1991). Past research has found that ratings from this interview predict inflammatory measures such the *in vitro* production of cytokines in asthma patients and IL-6 in response to bacterial stimulation in healthy adults (Marin, Chen, Munch, & Miller, 2009; Miller, Rohleder, & Cole, 2009).

Frequency of help provided to family. In the daily diary, adolescents were also asked, "How much time did you spend helping family today?" They were allowed to respond in hours and minutes. Because most adolescents endorsed providing at least some help to their family each day and because the time spent helping ranged from minutes to multiple hours (average amount of time helping was in the one hour range for each of the daily diary days), we simplified this measure by recoding each child's daily reported time into a categorical variable where 1 was more than one hour of helping the family in a day and 0 was one hour or less of helping the family in a day. Then, as with the frequency of demands from family, a helping frequency score was computed by dividing the number of days on which more than one hour of help was provided by the total number of days on which the daily diary was completed.

Outcome Variables

We assessed two types of markers related to proinflammatory phenotypes: chronic low-grade inflammation and cytokine production of immune cells in response to bacterial stimulation. Low-grade inflammation is a measure of resting or basal levels of inflammation in circulation, whereas stimulated cytokine production is a functional measure that indicates how immune cells respond to threats.

Low-grade inflammation. Low-grade inflammation was assessed as a composite of basal IL-6 and CRP. Peripheral blood was drawn into serum separator tubes (SSTs; Becton-Dickinson, Franklin Lakes, NJ). Between 60 and 120 min after the blood draw, SST tubes were spun for 10 min at 1,200 g and blood serum was aliquoted and stored at -30°C . IL-6 was measured using a high-sensitivity ELISA kit (R&D Systems, Minneapolis, MN; intraassay coefficient of variation [CV] <10%; detection threshold = .04 pg/ml). CRP was measured from serum using a high-sensitivity, chemiluminescent technique on an Immulite 2000 (Diagnostica Products Corporation, Los Angeles, CA; interassay CV = 2.2%; detection threshold = .20 mg/L). IL-6 and CRP scores were standardized and averaged to create a composite, $r = .42$, $p < .001$. This low-grade inflammation composite reflected heightened risk for cardiovascular disease (Danesh et al., 2004; Ridker, Buring, Shih, Matias, & Hennekens, 1998; Ridker, Rifai, Stampfer, & Hennekens, 2000; Yudkin, Kumari, Humphries, & Mohamed-Ali, 2000).

Stimulated cytokine production. To assess the functioning of immune cells—that is, stimulated cytokine production in response to a microbial challenge—peripheral blood was drawn into sodium-heparin Vacutainers (Becton-Dickinson) and diluted 10% with an isotonic saline solution. Blood was then mixed with 400 μl of a bacterial stimulus, LPS saline solution, for a final concentration of 50 ng/mL LPS, and incubated for 6 hr at 37°C at 5% carbon dioxide. Supernatants were collected and frozen at -30°C until further analysis. Levels of the proinflammatory cytokines IL-1 β , IL-6, IL-8, IL-10, and TNF- α were measured in duplicate with Meso Scale Discovery Human (MSD) ProInflammatory 7-Plex Base Kits (MSD, Rockville, MD), with a minimum detection threshold of 0.15 pg/ml. Interassay and intraassay CVs were less than 10%. Stimulated cytokine production was only assessed in a subset of participants ($N = 143$) for cost purposes (these participants were randomly selected from the larger sample). These cytokine values in response to bacterial stimulation were highly correlated with each other (as displayed in Table 2). Thus, we created a stimulated cytokine composite by first standardizing each cytokine value and then averaging these standardized variables together ($\alpha = .79$). Immune cells that display more exaggerated reactivity to an equivalent dose of threat (bacterial stimuli) are thought to contribute to a proinflammatory phenotype that, over time, fosters ongoing inflammation and contributes to chronic diseases of aging (Miller, Chen, & Parker, 2011).

Covariates

Covariates in this study included age, gender, ethnicity (White vs. not White), highest degree that the parent had attained (1 = *less than a high school diploma*, 2 = *high school diploma*, 3 = *some college*, 4 = *BA*, 5 = *graduate school*), and body mass index (BMI).

Plan of Analysis

In order to test whether frequency of demands predicted greater inflammatory profiles and whether this relationship was moderated by family closeness and/or frequency of helping, multiple hierarchical linear regressions were conducted separately for each moderator (frequency of helping or quality of relationship with family)

and outcome. Age, gender (male = 0, female = 1), ethnicity (not White = 0, White = 1), parents' highest degree, and BMI were entered in Step 1. Then, to test whether frequency of demands predicted greater inflammatory profiles, frequency of demands was entered in Step 2. The moderator (either family closeness scores or frequency of help provided) was entered in Step 3, and the interaction between frequency of demands and the moderator was entered in Step 4. All continuous predictor variables were standardized.

Results

Descriptive statistics for the sample are presented in Table 1, and correlations among the variables are presented in Table 2.

As expected, the frequency with which adolescents' families made demands on them predicted higher scores on the low-grade inflammation composite, $b = .16$, $SE = .06$, $t(225) = 2.83$, $p = .005$, $sr^2 = .03$. In addition, consistent with our expectations, the frequency with which adolescents' families made demands on them predicted marginally higher scores on the stimulated cytokine composite, $b = .12$, $SE = .07$, $t(125) = 1.86$, $p = .07$, $sr^2 = .02$.

Demand Frequency by Family Closeness Interactions

When closeness of family relationships was entered into the equations, there was no main effect on either the low-grade inflammation composite, $b = .02$, $SE = .06$, $t(224) = .56$, $p = .58$, $sr^2 = .001$ or the stimulated cytokine composite, $b = .02$, $SE = .07$, $t(124) = .26$, $p = .79$, $sr^2 < .001$. However, family relationship closeness did moderate the relationship between frequency of demands and the stimulated cytokine composite, $b = .19$, $SE = .06$, $t(123) = 2.89$, $p = .005$, $sr^2 = .06$. Simple slope analyses to explore the nature of the interaction indicated that as relationship closeness increased, the relationship between frequency of de-

mands and stimulated proinflammatory cytokine production became more positive. Specifically, when adolescents had closer relationships, frequency of demands predicted higher levels of the stimulated cytokine composite, $b = .31$, $SE = .09$, $t(123) = 3.45$, $p = .001$, $sr^2 = .08$, but when they had family relationships that were less close, frequency of demands did not predict the stimulated cytokine composite, $b = -.06$, $SE = .10$, $t(123) = -.61$, $p = .55$, $sr^2 = .003$. Contrary to our expectations, relationship closeness did not moderate the effect of demands on the low-grade inflammation composite, $b = -.01$, $SE = .05$, $t(223) = -.11$, $p = .54$, $sr^2 < .001$ (Table 3).

Demand Frequency by Help Provided Interactions

When frequency of helping one's family was entered into the equations, there was no main effect on either the low-grade inflammation composite, $b = .04$, $SE = .06$, $t(225) = .75$, $p = .46$, $sr^2 = .002$, or the stimulated cytokine composite, $b = -.03$, $SE = .07$, $t(124) = -.42$, $p = .68$, $sr^2 = .001$. However, as expected, frequency of helping one's family did moderate the effect of demands on both the low-grade inflammation composite, $b = .12$, $SE = .05$, $t(224) = 2.26$, $p = .03$, $sr^2 = .02$, and the stimulated cytokine composite, $b = .17$, $SE = .07$, $t(123) = 2.62$, $p = .01$, $sr^2 = .05$. Simple slope analyses to explore the nature of these interactions indicated that as frequency of helping one's family increased, the relationship between frequency of demands from one's family and the outcomes became stronger. Specifically, when adolescents provided more help, frequency of demands positively predicted the low-grade inflammation composite, $b = .26$, $SE = .07$, $t(224) = 3.57$, $p < .001$, $sr^2 = .05$, and positively predicted the stimulated cytokine composite, $b = .32$, $SE = .10$, $t(123) = 3.30$, $p = .001$, $sr^2 = .07$, but when adolescents provided less help to the family, frequency of demands predicted neither the low-grade inflammation composite, $b = .03$, $SE = .08$, $t(224) = .37$, $p = .71$, $sr^2 = .001$, nor the stimulated cytokine composite, $b = -.03$, $SE = .09$, $t(123) = -.27$, $p = .79$, $sr^2 < .001$. See Table 3 and Figure 1.

Supplemental analyses. In addition, in order to test whether children's depressive symptoms might underlie the relationships observed here, we reran analyses, controlling for children's scores on the Center for Epidemiological Studies Depression Scale (Radloff, 1977). When depressive symptoms were added as a covariate, family relationship closeness still moderated the relationship between frequency of demands and the stimulated cytokine composite, $b = .21$, $SE = .07$, $t(122) = 3.22$, $p = .002$, $sr^2 = .07$. In addition, frequency of helping one's family still moderated the effect of demands on both the low-grade inflammation composite, $b = .12$, $SE = .05$, $t(223) = 2.19$, $p = .03$, $sr^2 = .02$, and the stimulated cytokine composite, $b = .17$, $SE = .07$, $t(122) = 2.47$, $p = .03$, $sr^2 = .04$.

Discussion

Although there are well-documented benefits of close relationships (Cohen & Wills, 1985), the current research suggests that such relationships may carry costs under certain circumstances. Among adolescents with close family relationships, experiencing frequent daily demands was related to greater LPS-stimulated production of proinflammatory cytokines. In contrast, among ad-

Table 1
Descriptive Statistics

Measure	N	M or %	SD
Age (years)	234	14.53	1.06
Gender (% male)	234	47.86	
Ethnicity (% White)	234	50.00	
Parent's highest degree (% bachelor's)	234	64.10	
BMI (kg/m ²)	234	21.28	3.67
Days family made demands (%)	234	.24	.29
Child helped family (%)	234	.37	.33
Family closeness	233	3.90	.70
Low-grade inflammation			
IL-6 (pg/ml)	232	.94	1.04
CRP (mg/L)	233	.96	3.54
LPS stimulated cytokine production			
IL-1 β (pg/ml)	132	7,372.57	6,087.50
IL-6 (pg/ml)	132	33,933.61	10,911.17
IL-8 (pg/ml)	131	18,788.78	11,604.53
IL-10 (pg/ml)	132	216.34	124.46
TNF- α (pg/ml)	132	14,920.51	7,415.54

Note. BMI = body mass index; CRP = C-reactive protein; LPS = lipopolysaccharide; IL-1 β = interleukin 1 beta; IL-6 = interleukin 6; IL-8 = interleukin 8; IL-10 = interleukin 10; TNF- α = tumor necrosis factor alpha.

Table 2
Correlations Among Primary Variables

Measure	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1. Age																	
2. Gender	-.03																
3. Ethnicity	.03	.00															
4. Parent highest degree	-.13 [†]	-.05	-.16*														
5. BMI	.22**	-.002	.02	-.18**													
6. Demands	-.13*	.12 [†]	-.03	-.1 [†]	-.01												
7. Help	-.05	.08	-.11	-.01	.17*	.13*											
8. Family closeness	-.10	-.11 [†]	.14*	.07	-.04	-.08	.09										
9. Basal IL-6	-.13*	.08	.05	-.20**	.18**	.21*	.06	.02									
10. CRP	.02	.00	.00	-.10	.09	.14*	.10	.008	.42***								
11. Low-grade inflammation	-.07	.05	.03	-.18**	.16*	.21**	.09	.02	.84***	.84***							
12. Stimulated IL-1β	-.001	.008	.10	-.14	.20*	.16 [†]	-.05	.05	.27***	.23***	.28***						
13. Stimulated IL-6	.07	-.10	.11	-.14	.24**	.15 [†]	-.04	.04	.32***	.28***	.34***	.69***					
14. Stimulated IL-8	.06	-.07	.02	-.08	.33**	.07	-.03	.006	.24**	.12	.20*	.52***	.62***				
15. Stimulated IL-10	-.02	-.02	.20*	-.11	.10	.90	-.03	.03	.07	.03	.05	.25**	.46***	.52***			
16. Stimulated TNF-α	.05	-.24**	.02	-.08	.10	.15 [†]	.01	.05	.29***	.31***	.35***	.62***	.84***	.49***	.37***		
17. Stimulated cytokine composite	.04	-.11	.12	-.13	.24**	.15 [†]	-.03	.05	.30***	.24***	.31***	.78***	.91***	.80***	.66***	.84***	

Note. BMI = body mass index; CRP = C-reactive protein; IL-1β = interleukin 1 beta; IL-6 = interleukin 6; IL-8 = interleukin 8; IL-10 = interleukin 10; TNF-α = tumor necrosis factor alpha.
[†] $p < .10$. * $p < .05$. ** $p < .01$. *** $p < .001$.

olescents who were less close to their families, frequency of demands showed little relationship to proinflammatory cytokine production. In addition, among adolescents who engaged in high levels of daily helping behaviors, but not among those who pro-

vided less frequent help, frequent demands from their families were associated with higher levels of low-grade inflammation and greater production of proinflammatory cytokines. Conversely, when family demands were less frequent, adolescents who pro-

Table 3
Regression Analyses

Predictor	Low-grade inflammation composite				Stimulated cytokine composite			
	Model 1 <i>b</i> (SE)	Model 2 <i>b</i> (SE)	Model 3 <i>b</i> (SE)	Model 4 <i>b</i> (SE)	Model 1 <i>b</i> (SE)	Model 2 <i>b</i> (SE)	Model 3 <i>b</i> (SE)	Model 4 <i>b</i> (SE)
Interactions between frequency of demands and closeness of relationship with family								
Age	-.10 (.06) [†]	-.08 (.06)	-.08 (.06)	-.08 (.06)	-.02 (.07)	.003 (.07)	.004 (.07)	-.01 (.07)
Gender	.06 (.11)	.03 (.11)	.04 (.11)	.04 (.11)	-.14 (.14)	-.17 (.14)	-.17 (.14)	-.13 (.14)
Ethnicity	.01 (.11)	.02 (.11)	.01 (.11)	.01 (.11)	.14 (.14)	.15 (.14)	.15 (.14)	.17 (.14)
Parent highest degree	-.13 (.06)*	-.11 (.06)*	-.12 (.06)*	-.12 (.06)*	-.06 (.07)	-.03 (.07)	-.03 (.07)	-.03 (.07)
BMI	.13 (.06)*	.13 (.06)*	.13 (.06)*	.13 (.06)*	.18 (.07)*	.18 (.07)*	.18 (.07)*	.20 (.07)**
Demand frequency		.15 (.05)**	.16 (.06)**	.16 (.06)**		.14 (.07)*	.14 (.07)*	.13 (.07) [†]
Family closeness			.03 (.06)	.03 (.06)			.02 (.07)	.02 (.07)
Demands × Closeness				-.01 (.05)				.19 (.06)**
R ² change		.03**	.001	0		.03*	0	.06**
Interactions between frequency of demands and frequency of help provided								
Age	-.10 (.06)	-.08 (.06)	-.08 (.06)	-.07 (.06)	-.02 (.07)	.003 (.07)	.01 (.07)	<.001 (.07)
Gender	.06 (.11)	.03 (.11)	.03 (.11)	.02 (.11)	-.14 (.14)	-.18 (.14)	-.18 (.14)	-.17 (.13)
Ethnicity	.01 (.11)	.02 (.11)	.03 (.11)	.01 (.11)	.14 (.14)	.15 (.14)	.14 (.14)	.12 (.14)
Parent highest degree	-.14 (.06)*	-.11 (.06)*	-.12 (.06)*	-.12 (.06)*	-.06 (.07)	-.03 (.07)	-.04 (.07)	-.06 (.07)
BMI	.13 (.06)*	.13 (.06)*	.13 (.06)*	.12 (.06)*	.18 (.07)*	.18 (.07)*	.19 (.07)*	.20 (.07)*
Demand frequency		.15 (.05)**	.15 (.06)**	.15 (.05)**		.14 (.07)*	.14 (.07)*	.15 (.07)*
Help frequency			.04 (.06)	.04 (.06)			-.04 (.07)	-.03 (.07)
Demands × Help				.12 (.05)*				.17 (.07)*
R ² change		.03**	.002	.02*		.03*	.003	.05*

Note. The table shows regression coefficients for the analyses predicting the low-grade inflammation composite (left) and the stimulated cytokine composite (right). Regression coefficients for the analyses testing whether the closeness of the family relationship moderates the relationship between the frequency of demands and each outcome are at the top, and those for the analyses testing whether the frequency of help provided to eh family moderates the relationship between frequency of demands and each outcome are at the bottom. Age, gender, ethnicity, parent’s highest degree, and body mass index (BMI) were entered in Model 1, followed by frequency of demands and either frequency of help or family relationship closeness in Model 2, followed by the interaction between frequency of demands and either frequency of help or family relationship closeness in Model 3.
[†] $p < .10$. * $p < .05$. ** $p < .01$. *** $p < .001$.

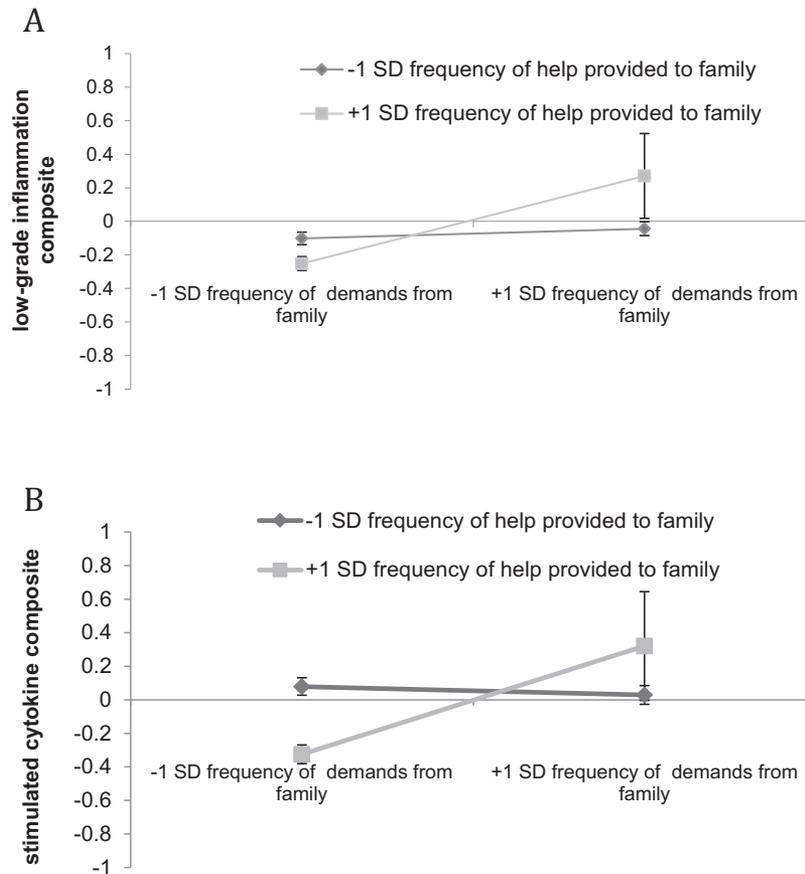


Figure 1. (A) Low-grade inflammation composite and (B) stimulated cytokine composite values as a function of how frequently families made demands on adolescents and how frequently they provided help to their families. Error bars represent ± 1 standard deviation.

vided more frequent help to family members had lower levels of low-grade inflammation and lower production of proinflammatory cytokines, relative to those adolescents who engaged in fewer helping behaviors. These findings build on previous research suggesting that demands from close others can be detrimental to health by revealing that such correlations emerge under specific types of circumstances in specific types of relationships.

Thus, the nature of the interaction between frequency of demands and closeness to one's family supports the second of our two competing hypotheses, that frequent demands are physiologically detrimental when adolescents are close to their families. There was little evidence of the alternative hypothesis: that close family relationships would buffer against the stress of frequent demands from family members. Although close relationships have been found to buffer against other types of stress (Uchino, 2006), these relationships may not provide as much of a buffer when the relationships themselves (i.e., the demands) are the source of the stress. Instead, frequent demands from others may predict higher levels of LPS-stimulated cytokine production among adolescents with close family relationships because such closeness creates an especially strong sense of obligation to meet the demands. Although adolescents who are close to their families may derive some benefit from feeling understood and supported, the sense of

obligation that stems from closeness could make frequent demands especially physiologically detrimental (Chen, Brody, & Miller, in press). Adolescents who are close to their parents may be especially attuned to their parents' needs or aware of the potential importance of their contributions to the family. They might also believe that they are uniquely suited to help their families and, thus, worry that, without their contribution, their families' demands could go unmet. As a result, they might feel strongly compelled to give of themselves in order to meet their parents' demands. Putting their families before themselves in this way could have negative implications for their health (Helgeson, 1994).

With respect to our competing hypotheses about the nature of the interaction between frequency of demands and frequency with which adolescents provide help to their families, the results also lend support to our second of two competing hypotheses, namely, that frequent demands are detrimental when adolescents are already providing frequent help. Although it might have been plausible that adolescents would derive a sense satisfaction, purpose, or meaning from helping frequently when such help was demanded, and thus have more beneficial inflammatory profiles, there was little evidence for such a pattern. Instead, the combination of having frequent demands made by one's family and providing frequent help to one's family predicted worse inflammatory pro-

files. This might have occurred because this combination places a large burden on adolescents. For example, adolescents who help their families a lot and, at the same time, experience additional demands from their families may feel overwhelmed by the large number of responsibilities. It might also be the case that when a family recognizes that an adolescent is especially helpful, family members tend to turn to this adolescent more frequently with additional demands. Such a tendency could, in turn, create a cyclical process where the adolescent helps more and then has more demands made, eventually feeling overly burdened or trapped in their role. As a result, adolescents in such situations might not be able to prioritize their own needs or to engage in restorative leisure activities (e.g., time with friends) that could have protective effects on their own health. In contrast, helping one's family without having high demands made might give adolescents a sense of meaning or purpose that comes from freely choosing to contribute to one's family (Fulgini et al., 2009).

We note here that we have described the existence of high levels of low-grade inflammation and proinflammatory cytokine production in response to bacterial stimulation as detrimental. This is in line with literature that conceptualizes inflammation as detrimental and links it to cardiovascular disease and other chronic diseases of aging (Danesh et al., 2004; Libby, Ridker, Hansson, & the Leducq Transatlantic Network on Atherothrombosis, 2009; Miller, Chen, & Parker, 2011; Nathan & Ding, 2010; Ross, 1999; Scivo, Vasile, Bartosiewicz, & Valesini, 2011; Woollard, & Geissmann, 2010; Yudkin, Kumari, Humphries, & Mohamed-Ali, 2000). While this literature has focused primarily on adult samples, the proinflammatory tendencies that are associated with poor health outcomes down the line are thought to develop in childhood (Miller et al., 2011). Furthermore, higher levels of inflammation in adolescence predict other indicators of cardiovascular risk, such as greater carotid intima-media thickness (Järvisalo et al., 2002; Pirkola et al., 2010), and individuals who have high levels of inflammation as adolescents tend to also have high levels as adults (Juonala et al., 2006). At the same time, we acknowledge that it is adaptive to mount acute inflammatory responses to challenge, which means that a precise understanding of what levels of inflammation might be adaptive versus excessive can be challenging to ascertain, particularly in healthy adolescent samples.

Furthermore, it is notable that the processes that we describe above may be especially relevant during adolescence, which is a developmental period that prioritizes autonomy (Zimmer-Gembeck & Collins, 2003). Even though relationships with parents often remain strong, during the course of adolescence, time spent with families progressively decreases, in favor of spending more time on activities and relationships outside of the home and developing stronger relationships with peers (Furman & Buhrmester, 1992; Larson, Richards, Moneta, Holmbeck, & Duckett, 1996). Adolescents who feel especially obligated to meet their families' demands, as a result of being close to their families, could miss out on the opportunities to develop stronger relationships outside of their families or spend time with peers. Similarly, adolescents who are burdened by additional family demands when they are already providing frequent help may have limited chances to spend time or develop relationships outside of the family context.

Limitations

This research does, however, have limitations. One is that the findings are correlational and, thus, it is not possible to know about causality or even directionality. Third variables could explain some of the relationships observed here. For example, poor relationships with peers might contribute both to adolescents spending more time at home and, thus, experiencing more family demands, as well as to worse inflammatory profiles.

Another set of limitations relates to the assessment of family demands and adolescent helping. First, both were assessed using self-report measures. It is possible that the same request (e.g., to do chores around the house) might be construed as a demand by some adolescents but not by others. As a result, it is unclear whether adolescents who report frequent demands are those who are actually subject to them or those who are more likely to construe their families' requests as demands. Second, both the family demands and adolescent helping were assessed using single-item questions answered as part of a daily diary protocol. Thus, we could not explore the role of factors such as the type of demand that was made (e.g., what task the child was asked to do) or how the demand was phrased (e.g., whether the family member said "please" or "thank you"). We also do not know how many demands were made each day. The use of a single item is a limitation inherent to daily diary designs, where questions tend to be brief in order to not overburden participants who are answering them every day, but, here, it also limits the extent to which more nuanced information about demands was available.

Finally, the present study assessed inflammation, rather than clinical health outcomes. Inflammation is a precursor to cardiovascular disease and other chronic diseases of aging (Libby et al., 2009; Scivo et al., 2011; Woollard & Geissmann, 2010), which suggests that the adolescents in this study with greater inflammatory profiles might be at risk for cardiovascular disease down the line. Future research could test this possibility, possibly by tracking adolescents over time to see if they developed cardiovascular disease. Alternatively, adults who had and had not developed cardiovascular disease could be asked to retrospectively report on the frequency of demands from their family, frequency of help provided to their family, and the closeness of their relationships with their families during adolescence.

Future Directions

Future research could address the limitations of the current work. In order to better understand the causal direction of the relationships observed here, experimental work could manipulate the variables thought to drive worse physiological outcomes. For example, researchers might see whether decreasing the daily demands made on adolescents could improve their inflammatory profiles over time, especially if these adolescents are already providing a lot of help to their families or are close to their families.

In order to address the self-report limitation of how family demands and helping behaviors were assessed, future research might benefit from also assessing parent reports of demands and helping behaviors. Alternatively, it could be informative to record family conversations to more objectively assess what parents are actually demanding of their children. Such assessments could help to elucidate whether it is the demands themselves, or merely the perception of having demands made, that correlates with worse

inflammatory profiles. Such an approach might also provide data on tone or language that family members used to make demands, which could vary with factors such as the closeness of the family relationship and might also affect the child's experience of having the demands made.

There are also additional questions to explore related to how these processes unfold over time. For example, the present research shows that adolescents who report both frequent demands made by family members and frequent help provided to family members have worse inflammatory profiles. One possible way in which frequent demands and frequent help provided could work together to relate to inflammation is that some adolescents who are already providing a lot of help have further demands placed upon them. This would increase their sense of burden or stress, and then gives rise to worse inflammatory profiles. Another possibility is that family members make demands and that adolescents provide help in response to those demands. The burden of providing help that is demanded, rather than freely given, might then give rise to worse inflammatory profiles. Repeated assessments about the nature and timing of the demands and helping behaviors (e.g., whether specific helping behaviors were provided in response to a specific demands or were exhibited spontaneously) could help to disentangle these possibilities.

Further exploration of how these processes unfold over time could also include investigating in more detail the psychological mechanisms by which frequent demands relate to worse inflammatory profiles. This might involve assessing adolescents' sense of obligations to their family, fears of disappointing their family, and perceived burden in response to their family's demands, as well as adolescents' available time for leisure activities.

The present research could also be extended by further investigating the role played by other characteristics of the family. One important factor to consider is the family's ethnic background, which previous research shows can influence the way children construe family obligations (Fuligni, Tseng, & Lam, 1999). Another factor that may make a difference is what other stressors a family is coping with. For example, in families where financial resources are limited or someone is experiencing a major illness and needs care, adolescents might be faced with very frequent demands and feel especially obligated to help. As a result, some of the effects observed here could be especially strong under such circumstances.

Finally, future research could investigate whether it matters who is making the demands (e.g., mother, father, sibling) or how many family members are making demands. For example, it is possible that the effects of one family member making frequent demands could be buffered by another family member who is not demanding. The present findings could be extended outside of the family context to other types of relationships, as well. Previous research shows that demands are correlated with worse health outcomes among people in a range of close relationships (Brooks & Dunkel Schetter, 2011; Weinstein et al., 2003). Additional research could thus explore whether the findings observed here would extend to spouses or close friends.

Conclusion

Despite its limitations, this study makes new contributions that have implications for our understanding of the role of family

relationships in health. The findings build on previous literature documenting that family demands are associated with poor health outcomes by revealing that this relationship occurs under specific circumstances, namely, in the context of close relationships with family members who are making the demands and when those who experience frequent demands are also providing frequent help. Taken together, these patterns highlight how close relationships, such as those within a family, might come with a cost for adolescent inflammatory profiles relevant to health, particularly if families impose too many demands on their children.

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