Brain, Behavior, and Immunity 23 (2009) 803–809

Contents lists available at ScienceDirect

Brain, Behavior, and Immunity

journal homepage: www.elsevier.com/locate/ybrbi

Daily family assistance and inflammation among adolescents from Latin American and European backgrounds

Andrew J. Fuligni [a,b,d,*], Eva H. Telzer [b], Julienne Bower [a,b,d], Michael R. Irwin [a,d], Lisa Kiang [c], Steve W. Cole [a,d,e]

[a] Department of Psychiatry & Biobehavioral Sciences, University of California, Los Angeles, USA
[b] Department of Psychology, University of California, Los Angeles, USA
[c] Department of Psychology, Wake Forest University, USA
[d] Norman Cousins Center for Psychoneuroimmunology, University of California, Los Angeles, USA
[e] Department of Medicine, Division of Hematology-Oncology, UCLA School of Medicine, HopeLab Foundation, Jonsson Comprehensive Cancer Center, UCLA AIDS Institute, UCLA Molecular Biology Institute, USA

ARTICLE INFO

Article history:
Received 9 December 2008
Received in revised form 27 February 2009
Accepted 28 February 2009
Available online 9 March 2009

Keywords:
Family assistance
Inflammation
Adolescents
Latinos
European Americans
Ethnicity

ABSTRACT

To assess the biological impact of time spent helping the family during the teenage years, we examined circulating levels of interleukin-6 (IL-6), soluble interleukin-6 receptor (sIL-6r), and C-reactive protein (CRP) in 64 adolescents (M_{age} = 17.79 years) from Latin American and European backgrounds. Analyses of nightly diary checklists over 14 days showed that the amount of time spent helping the family in a variety of ways, such as cooking, cleaning, and sibling care, was associated with long-term elevations of sIL-6r and CRP, even after controlling for ethnicity, parental education, BMI, substance use, distress, and frequency of daily family assistance 2 years earlier. However, adolescents who derived a greater sense of role fulfillment from helping the family on a daily basis had lower levels of sIL-6r and CRP as compared to their peers who engaged in the same amount of family assistance. Additional work should explore the family context that drives high levels of assistance among adolescents, as well as the variety of ways adolescents may derive meaning from this activity.

1. Introduction

Family assistance is an understudied yet significant aspect of family interactions during the adolescent years. Providing support and assistance to other family members are important activities of teenagers in the United States, sometimes taking up as much time as socializing with friends and studying for school (Hardway and Fuligni, 2006). Tasks such as caring for siblings, cooking and cleaning, and running errands for parents are particularly common among adolescents from Latin American backgrounds. Due to a combination of cultural traditions, immigrant status, family size, and economics, American families from Mexican and other Latin American backgrounds place a stronger importance upon the role of children and adolescents to assist in the maintenance of the household (García Coll and Vázquez García, 1995). As a result, adolescents from these groups spend up to twice the amount of time helping other family members as compared to their peers from European backgrounds (Hardway and Fuligni, 2006).

The implications of high levels of family assistance for the health and well being of adolescents are currently unknown. Membership in families with difficult social and economic environments during childhood has been linked to elevated levels of inflammation later during adulthood (Taylor et al., 2006). Among adults, high levels of family caregiving have been shown to be associated with both self-reported poor health and biomarkers of compromised immune function and heightened cardiovascular risk (Vitiliano et al., 2003). For example, Kiecolt-Glaser et al. (2003) observed elevated levels of the pro-inflammatory cytokines IL-6 among adults caring for a spouse with dementia. Yet virtually all of this work has been conducted among adults and much of it has focused on caring for the elderly, particularly those with a challenging debilitating condition such as dementia. It is unknown whether similar patterns would be observed among a sample of adolescents engaging in more normative types of family assistance. Given increased interest in the early detection of risk factors for cardiovascular disease (CVD) and other inflammation-related health issues, it would be important to examine this potential risk factor during the adolescent years (Williams et al., 2002).

Consistent with the research on adults, high levels of family assistance during the teenage years may have negative implications for health. Cooking, cleaning, and caring for siblings can be

* Corresponding author. Address: University of California, 760 Westwood Plaza, Box 62, Los Angeles, CA 90024, USA. Fax: +1 310 794 6297.
E-mail address: afuligni@ucla.edu (A.J. Fuligni).

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doi:10.1016/j.bbi.2009.02.021

burdensome and stressful for adolescents who face the competing demands of being a teenager, such as studying for school and socializing with friends (Burton, 2007; Chase, 1999). Such an impact could be evident in elevated levels of inflammation, which have been shown to be upregulated among individuals facing chronic levels of strain and activation of the hypothalamic–pituitary–adrenal axis, such as those who engage in long-term care and family assistance (Kiecolt-Glaser et al., 2003). On the other hand, family assistance may show no link with increased inflammation during adolescence. Activities such as caring for siblings and housework are likely to be less stressful than caring for debilitated family members and the general health of teenagers may be robust enough to avoid being negatively impacted by family assistance. In addition, family assistance can be a meaningful activity for adolescents as it provides a sense of purpose and role fulfillment for teenagers, particularly those from groups such as Latin Americans who strongly value such activities. Deriving a sense of meaning and purpose from life stressors has been shown to be associated with better health outcomes (Bower et al., 2003), and the same may be true for family assistance during adolescence.

The current study examined the associations between the daily family assistance of a sample of adolescents from Latin American and European backgrounds and their circulating levels of interleukin-6 (IL-6), the soluble interleukin-6 receptor (sIL-6r), and C-reactive protein (CRP). IL-6 is a pro-inflammatory cytokine that has been shown to be related to caregiving (Kiecolt-Glaser et al., 2003), sIL-6r enhances IL-6 activity as it allows it access into cells that don't bear the receptor themselves (Kallen, 2002), and CRP is a relatively downstream indicator of chronic and elevated levels of IL-6 activity and has been shown to be a risk factor for the later development of CVD (Lagrand et al., 1999). The role played in the associations between family assistance and inflammation by factors such as parental education, obesity, and emotional distress were examined, as was the extent to which adolescents derived a sense of role fulfillment from providing assistance to the family.

A unique feature of the current study was the use of the daily diary method in which participants reported the occurrence of family assistance, emotional distress, and role fulfillment on a daily basis for a two-week period. The daily diary method is superior to traditional questionnaire techniques because it "captures life as it is lived" and is less susceptible to recall biases (Bolger et al., 2003). Previous analyses from the same study showed how daily reports of interpersonal conflict and harassment were more predictive of CRP than a traditional questionnaire measure of stressful life events (Fuligni et al., 2009), highlighting the value of employing such a direct measure of actual experience over more typical questionnaire inventories, which usually ask respondents to generalize their reports across time and experiences.

2. Methods

2.1. Sample and design

The sample of 64 adolescents in the current study is a subsample of a group of 383 adolescents from three high schools in the Los Angeles area who took part in a larger study of the daily experience of adolescents when they were in the 12th grade (M_{age} = 17.79 years in the 12th grade). The current sample consisted of 39 participants from Latin American backgrounds, most of whom (95%) reported Mexican as their ethnic background, and 25 participants from a mix of European backgrounds (e.g., Irish, Jewish, German). All adolescents spoke and read English fluently, although this was not a requirement for participation in the study. The full sample was 56.2% female with the gender distribution more equal among those from Latin American backgrounds (49% female) than among those from European backgrounds (68% female).

During the spring of the 12th grade in 2006, participants filled out questionnaires during school hours and then completed a daily diary checklist each night before going to bed for 14 consecutive days. The diary checklists were only 3 pages long and took about 5–10 min to complete. In order to monitor completion of the diary checklists, participants were also provided with 14 manila envelopes and an electronic time stamper (Dymo Corporation, Stamford, CT). The time stamper is a small, hand-held device that imprints the current date and time and is programmed with a security code so that the correct date and time cannot be altered. Participants were instructed to place their completed diary checklist into a sealed envelope each night, and to stamp the seal of the envelope with the time stamper. At the end of the two-week period, the adolescents returned the completed materials to the school and received $30 for participating in the study. In addition, the adolescents were told that they would receive two movie passes if inspection of the data indicated that they had completed the diaries correctly and on-time. The time stamper method of monitoring the completion of the diaries and the cash and movie pass incentives resulted in a high rate of compliance, with 98.9% of the diaries being completed.

Of the total sample of 64, 54 participants completed identical diary checklists using the same protocol 2 years earlier during the spring of the 10th grade. These reports were used to conduct additional analyses controlling for stable individual differences in family assistance, and to examine the association of change in family assistance with inflammation.

In the fall and winter after the 12th grade, in 2006/2007, the participants were re-contacted and recruited to participate in an additional round of data collection. Participants came to a lab at the University of California, Los Angeles (UCLA) where they completed questionnaires, had height and weight measurements taken using a stadiometer, and provided blood samples for the evaluation of IL-6, sIL-6r, and CRP. Appointments took place an average of 7.79 months (Range: 3.93 months to 12.24 months) after the participants completed their questionnaires and diary checklists during the 12th grade. Blood samples were drawn at a variety of times during the day, with the majority (84.7%) being obtained between the hours of 12:00 pm and 4:45 pm. The modal time was 1:30 pm. All procedures were approved by the UCLA IRB, and all participants were over 18 years of age at the time of data collection.

2.2. Social and behavioral measures

Participants reported their mother and father's highest educational attainment on the 12th grade questionnaire by responding to a scale that ranged from "elementary/junior high school," "some high school," "graduated from high school," "some college," "graduated from college," to "law, medical, or graduate school." A single measure of parental education was created by taking the mean of the standardized values of mother and father education.

Daily family assistance during the 12th grade was measured by a set of questions on the daily checklist that asked participants to indicate whether they did any of the following things to help their family each day: helped clean the apartment or house, took care of siblings, ran an errand for the family, helped siblings with their schoolwork, helped parents with official business (for example, translating letters, completing government forms), helped to cook a meal for the family, helped parents at their work, and other. Participants then estimated the total number of hours they had spent in all of the activities that day. The list of activities was derived from focus group studies of adolescents and has been used successfully in previous studies with these populations (Hardway and Fuligni, 2006).

Daily psychological distress during the 12th grade was assessed with items on the daily checklist that were obtained from the Profile of Mood States (Lorr and McNair, 1971). Adolescents used a five point scale (1 = "Not at all" to 5 = "Extremely") to indicate the extent to which they felt anxious and depressive feelings (items: "sad," "hopeless," "discouraged", "on edge," "unable to concentrate," "uneasy," "nervous"). Scores on the 7 items were averaged for each day, and then a mean level of daily distress was obtained by taking the average of scores across the 14 days. The alpha coefficient (.80) indicated that the measure possessed good internal consistency.

Daily role fulfillment was measured by asking adolescents to use a seven point scale (1 = "Not at all" to 7 = "Extremely") to report the extent to which they felt like "a good son or daughter" and "a good brother or sister." Scores across the items were averaged for each day and the mean level of role fulfillment was obtained by taking the average of the scores across the days. The alpha coefficient (.97) indicated that the measure possessed good internal consistency.

Finally, measures of smoking behavior and caffeine and alcohol use were obtained when participants completed the additional questionnaire before their blood samples were taken. Adolescents indicated how many days (0–7) in the past week they had any caffeinated drink such as coffee or cola, smoked cigarettes, or had a drink containing alcohol (beer, wine, a mixed drink, any kind of alcoholic beverage).

2.3. Measurement of body mass index

Body mass index (BMI) was measured using height and weight observations obtained using a stadiometer at the time of the blood collection, and was calculated by taking weight in pounds divided by the square of height in inches, multiplied by 703 to convert to metric units.

2.4. Measurement of inflammatory markers

Blood samples were drawn from participants through routine venipuncture after they completed the questionnaire and after height and weight measurements were taken. CRP was measured using high-sensitivity immunoassay on a BN-II System (Dade-Behring, Newark, DE). Samples were automatically diluted 1:20 with N Diluent. This technique has a limit of detection of 0.175 mg/L and intra- and inter-assay coefficients of variation of <4%, and all samples had detectable levels of CRP. Plasma levels of IL-6 and sIL-6r were determined in duplicate for each sample, using the Quantikine high-sensitivity human IL-6 and Quantikine human sIL-6r ELISA kits (R&D Systems, Inc., Minneapolis, MN), according to the manufacturer's protocol. The lower limits of detection (defined by the concentration of the lowest standard and any sample dilution) were 0.2 pg/ml (IL-6) and 3120 pg/ml (sIL-6r). Detectable levels were present for IL-6 and sIL-6r in all samples assayed.

2.5. Data analysis

Data were analyzed using SPSS for Windows, Version 15 (2006 SPSS Inc., Chicago, IL). Individual-levels of CRP were first examined for values above 10 mg/L, the value suggested the American Heart Association and the Centers for Disease Control and Prevention as being indicative of an acute inflammatory response (e.g., an infection) that would warrant exclusion from analyses such as these (Pearson et al., 2003). None of the participants had values of CRP that met this criterion. CRP was log transformed for the correlations, multiple regressions, and multi-level modeling described below.

Two-step hierarchical regressions were conducted in order to determine whether the association between family assistance and inflammation existed after first controlling for ethnicity, parental education, and BMI and then controlling for substance use and distress. An additional regression analysis addressed whether the change in family assistance from the 10th to 12th grade was associated with inflammation as a way to control for the possibility that any observed association was due to stable, long-term individual differences. Finally, Hierarchical Linear Modeling (Scientific Software, Chicago, IL) was employed in order to examine whether inflammation was associated with individual differences in the daily level association between family assistance and role fulfillment, the greater of which would indicate adolescents who derive more role fulfillment from helping the family.

3. Results

Overall, the means and standard deviations of the study variables portray a generally healthy sample (Table 1). There were no gender differences in any of the indicators of inflammation ($ts(57–62) = 1.27–1.81$, n.s.) and the only ethnic difference in inflammation was that those with Latin American backgrounds had significantly higher levels of IL-6 ($M = 1.43$, $SD = 0.80$) than those with European backgrounds ($M = 1.08$, $SD = 0.47$), $t(55.88) = 2.11$, $p < .05$. The sub-sample of 64 adolescents who participated in the current study spent significantly less time assisting the family than those who did not participate ($M = 1.04$, $SD = 0.91$, $t = 2.21$, $p < .05$), but did not differ in terms of distress or role fulfillment.

Males and females did not differ significantly in family assistance or any of the other predictors of inflammation, $ts(59–62) = 0.28–1.81$, n.s. A number of ethnic differences were evident such that adolescents from Latin American backgrounds spent more time helping the family ($M = 0.96$, $SD = 0.96$), had higher levels of BMI ($M = 27.46$, $SD = 8.58$), and used alcohol less often ($M = 0.85$, $SD = 1.35$) than those from European backgrounds ($Ms = 0.48$, 22.63, 1.84, $SDs = 0.40$, 3.93, 1.60, respectively), $ts(57.23–62) = 2.62–3.06$, $ps < .01–.05$. Adolescents from Latin American backgrounds also had parents with significantly lower levels of education ($M = -0.35$, $SD = 0.79$, standardized) than those with European backgrounds ($M = 0.55$, $SD = 0.40$, standardized), $t(54.72) = 5.89$, $p < .001$.

The correlations presented in Table 2 indicate that adolescents who spent more time helping the family per day had significantly higher levels of sIL-6r and CRP (also see Fig. 1a and b) and marginally higher levels of IL-6. Family assistance also was significantly associated with higher levels of BMI. Higher levels of BMI, in turn, were associated with greater IL-6, CRP, and marginally higher levels of distress. Distress also was related to significantly lower role fulfillment.

Table 1
Descriptives.

Variable	*M*	*SD*	Range
Family assistance	0.77	0.82	0–3.88
IL-6	1.28	0.70	0.31–4.00
sIL-6r	354.94	82.70	176.73–613.12
CRP	1.32	1.84	0.20–9.70
BMI	25.57	7.48	13.06–52.31
Parental education	0.02	0.80	−1.72–1.46
Caffeine use	3.31	2.30	0–7.00
Smoking	0.89	1.90	0–7.00
Alcohol use	1.23	1.52	0–5.00
Distress	1.53	0.42	1.00–3.05
Role fulfillment	4.35	1.20	1.46–7.00

Note: Family assistance is measured in hours per day; parental education is the mean of standardized reports of mother and father education; caffeine, smoking, and alcohol use are measured in days per week; distress is measured on a 1–5 scale and role fulfillment on a 1–7 scale.

Table 2
Correlations.

	1	2	3	4	5	6	7	8	9	10
1. Family assistance	–									
2. IL-6	.23^{+}	–								
3. sIL-6r	.35**	.21	–							
4. CRPlog	.38**	.39**	.45**	–						
5. BMI	.29*	.47***	.15	.51**	–					
6. Parental education	−.07	−.09	−.06	.06	−.17	–				
7. Caffeine use	−.24^{+}	.13	−.10	.07	.02	.03	–			
8. Smoking	.08	−.02	.06	−.02	−.03	.14	.22^{+}	–		
9. Alcohol use	−.07	−.37**	.16	.08	−.08	.17	.06	.14	–	
10. Distress	.06	−.04	.04	.09	.22^{+}	.09	−.14	−.02	−.03	–
11. Role fulfillment	.17	.02	.10	.06	−.13	.03	.02	.03	.18	−.40***

$^{+}$ $p < .10$.
* $p < .05$.
** $p < .01$.
*** $p < .01$.

3.1. Prediction of inflammation by family assistance

Multiple regression analyses in Table 3 indicate that the significant links between greater family assistance and higher levels of sIL-6r and CRP existed after controlling for adolescents' ethnicity, parental education, and BMI (Model 1). The association between family assistance and IL-6, however, was non-significant after accounting for these factors. As shown in Model 2 in Table 3, the prediction of sIL-6r and CRP also remained significant above and beyond adolescents' substance use and daily distress.

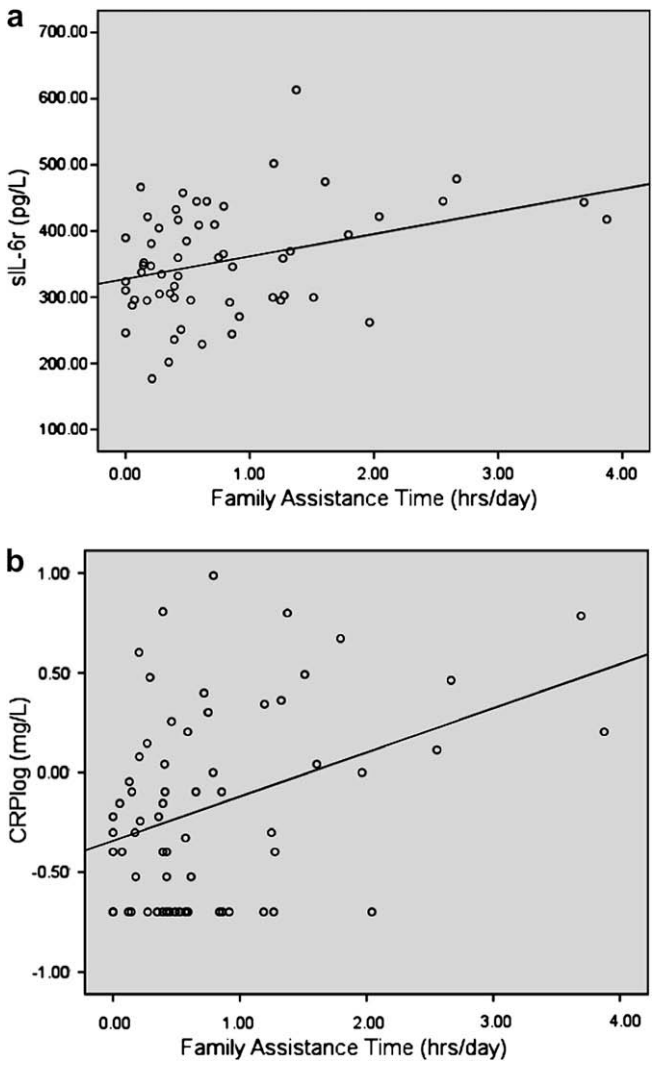

Fig. 1. (a) Levels of sIL-6r according to time spent helping the family. (b) Levels of CRP according to time spent helping the family.

Gender was not included in these regressions because of the earlier analyses that showed no gender differences in the indicators and predictors of inflammation. Additional analyses using the test of equal slopes in analyses of covariance (ANCOVA) showed that the links between family assistance and inflammation did not differ significantly between participants from different genders and ethnicities, Fs(1,55–60) = 0.25–1.52, n.s.

Because the blood samples were obtained at variable periods after the adolescents completed the reports of family assistance and at different times of the day, additional analyses were conducted in order to determine whether the observed associations with sIL-6r and CRP remained significant after controlling for the main effects of the number of months between the two measurements and the timing of the blood draw during the day, as well as whether the strength of the association between family assistance and inflammation varied according to the interval of measurement and the timing of the blood draw during the day.

The only significant interaction to emerge was that the strength between family assistance and CRP was stronger among those whose blood was obtained after more months had passed after the 12th grade, $\beta = .27$, $p < .05$. Even after controlling for this interaction and the main effect of the number of months between the measurements ($\beta = .26$, $p < .05$), however, the main effect of assistance time on CRP remained significant ($\beta = .45$, $p < .001$) indicating that the link between assistance and CRP existed across the sample even though it was stronger for those whose blood was obtained later. There was no interaction for either IL-6 or sIL-6r and the association of family assistance with sIL-6r and CRP remained significant even after controlling for the main effects of the interval of measurement and timing of the blood draw during the day.

Using the participants for whom an identical measure of family assistance was available at the 10th grade, a regression was conducted in which 10th grade level of family assistance was controlled while using 12th grade family assistance to predict sIL-6r and CRP. This allowed us to control for stable, individual differences and to examine the impact of change in family assistance on inflammation. Results indicated that the 12th grade measure was a significant predictor of sIL-6r ($\beta = .58$, $B = 54.61$, $SE = 15.54$, $p < .001$) and CRP ($\beta = .44$, $B = 1.00$, $SE = 0.39$, $p < .05$) whereas the 10th grade measure was not (βs = −.28, −.13, Bs = −25.56, −0.30, SEs = 15.09, 0.37, n.s.). These results were obtained despite the fact that the 10th grade and 12th grade measures of family assistance were highly correlated with one another ($r = .63$, $p < .001$).

Table 3
Inflammation according to family assistance, ethnicity, parental education, BMI, substance use, and distress.

	IL-6		sIL-6r		CRPlog	
	1	2	1	2	1	2
Intercept	1.23 (.09)	1.23 (.09)	354.70 (10.89)	354.11 (11.13)	−.16 (0.06)	−.16 (0.06)
Family assistance	.07 (.11)	.08 (.12)	32.67 (13.97)*	32.30 (14.90)*	.16 (.07)*	.18 (.08)*
	.08	*.09*	*.33*	*.32*	*.26*	*.29*
Ethnicity	−.04 (.12)	.00 (.12)	17.99 (15.12)	14.52 (16.20)	.09 (.07)	.06 (.08)
	−.05	*.00*	*.22*	*.18*	*.18*	*.13*
Parental education	.02 (.15)	.09 (.15)	−15.94 (18.57)	−14.88 (19.89)	−.04 (.08)	−.02 (.08)
	.02	*.09*	*−.15*	*−.14*	*−.06*	*−.03*
BMI	.04 (.01)**	.05 (.01)***	1.57 (1.55)	1.70 (1.72)	.03 (.01)***	.03 (.01)***
	.44	*.51*	*.15*	*.16*	*.51*	*.49*
Caffeine use		−.02 (.07)		−3.75 (12.30)		.06 (.06)
		−.04		*−.05*		*.12*
Smoking		.02 (.08)		−3.02 (10.96)		−.06 (.06)
		.03		*−.04*		*−.12*
Alcohol use		−.24 (.09)**		17.38 (11.68)		.06 (.06)
		−.33		*.21*		*−.12*
Distress		−.37 (.22)		−4.25 (29.69)		−.02 (.13)
		−.22		*−.02*		*−.02*

Note: Unstandardized regression coefficients and standard errors (in parentheses) are in the first line for each predictor, with the standardized beta coefficient immediately below in italics. All predictors are centered at the mean except for parental education, which is standardized, and ethnicity, which is coded −1 = Latin American, 1 = European.
* $p < .05$.
** $p < .01$.
*** $p < .01$.

3.2. Role fulfillment

Hierarchical Linear Modeling was used in order to examine whether a stronger connection between family assistance and role fulfillment on a daily basis was associated with lower levels of inflammation. Adolescents' reports of family assistance and role fulfillment were analyzed at the daily level across the fourteen daily reports. The following daily level equation was used to estimate the daily association of family assistance and role fulfillment:

$$\text{Role fulfillment}_{ij} = b_{0j} + b_{1j}(\text{Family assistance}) + b_{2j}(\text{Day of study}) + e_{ij} \quad (1)$$

Role fulfillment on a particular day (i) for a particular adolescent (j) was modeled as a function of the average role fulfillment of the individual across days (b_{0j}), the time adolescents spent assisting the family (b_{1j}) that day, and the day of the study (b_{2j}).

Within the same analysis, the link between inflammation and the daily association of assistance with role fulfillment was examined in the following individual-level equations:

$$b_{0j} = c_{00} + c_{01}(\text{Inflammation}) + c_{02}(\text{Average family assistance time}) + u_{0j} \quad (2)$$
$$b_{1j} = c_{10} + c_{11}(\text{Inflammation}) + c_{12}(\text{Average family assistance time}) + u_{1j} \quad (3)$$

Eqs. (2) and (3) show that the average level of role fulfillment (b_{0j}) and the daily association between assistance and role fulfillment (b_{1j}) were modeled as a function of inflammation. Each indicator of inflammation (IL-6, sIL-6r, and CRP) was standardized and treated as an individual predictor in three separate analyses.

Although it may seem unconventional to place inflammation as a predictor in these equations, given its hypothesized role as an outcome of family assistance, it is necessary to do so within a multi-level modeling framework in order to take advantage of the generalized least squares estimation to examine the association of an individual-level factor (i.e., inflammation) with the association between two factors that vary within the individual across days (i.e., family assistance and role fulfillment).

In addition, the average amount of time adolescents spent assisting the family across the two weeks was included in Eqs. (2) and (3) in order to account for the previously observed association between average assistance time and inflammation and to control for the possibility that the daily association between assistance time and role fulfillment would be stronger for adolescents who spend less time assisting the family.

Results indicated that on average, adolescents felt greater role fulfillment on days in which they spent more time helping the family (bs = .15–.17, SEs = .04, $p < .001$, across the three analyses involving each indicator of inflammation). In addition, the daily association between assistance and role fulfillment was significantly associated with both sIL-6r ($b = -.12$, $SE = .04$, $p < .01$) and CRP ($b = -.07$, $SE = .03$, $p < .05$), indicating that adolescents who obtained greater role fulfillment from daily assistance (i.e., a stronger positive daily association between the two) had significantly lower levels of inflammation than those who obtained less role fulfillment from these activities. As shown in Fig. 2a and b, adolescents with low levels of inflammation (i.e., −1 SD below the mean) have a stronger daily association between family assistance and role fulfillment than those with high levels of inflammation (i.e., +1 SD above the mean). The association for IL-6 was in the same direction ($b = -.04$, $SE = .02$) but did not reach statistical significance, $p = .11$. Because family assistance time was included in the models, these associations were independent of the average amount of time spent on family assistance across all 14 days, suggesting that adolescents who obtained more role fulfillment had lower levels of inflammation as compared to their peers who engaged in the same amount of family assistance.

Additional models that included interaction terms between inflammation and ethnicity and inflammation and gender indicated that the link between inflammation and the daily association between family assistance and role fulfillment did not vary by ethnicity and gender.

4. Discussion

Adolescents who spent more time assisting the family through activities such as cooking, cleaning, and sibling care exhibited elevated levels of inflammation independent of factors such as ethnicity, parental education, BMI, substance use, distress, and even frequency of daily family assistance 2 years earlier. These results are consistent with previous research conducted among adult caregivers of the elderly and the sick (Vitiliano et al., 2003) and were

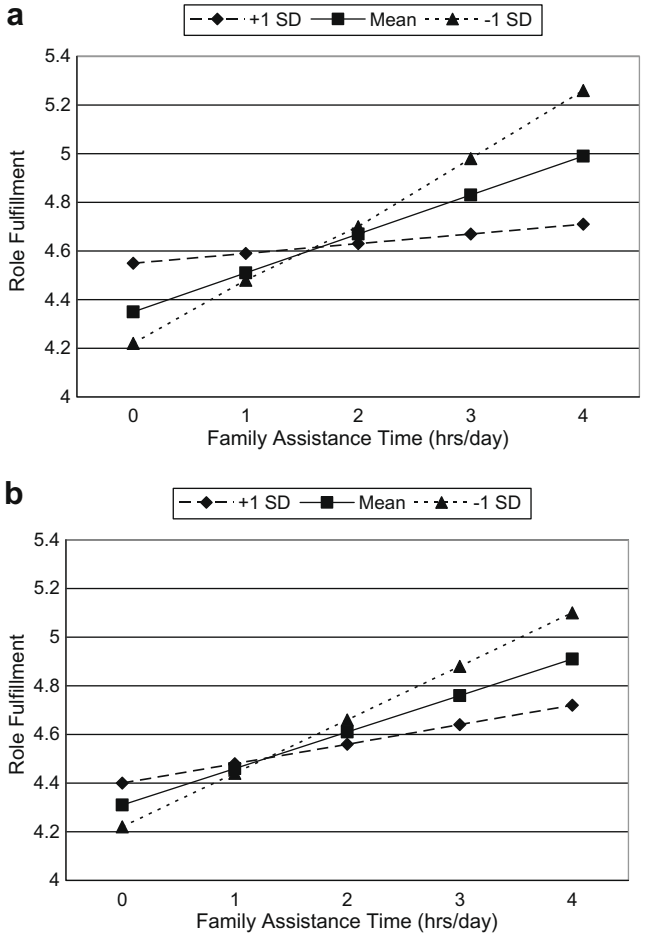

Fig. 2. (a) Daily association between family assistance and role fulfillment according to levels of sIL-6r. (b) Daily association between family assistance and role fulfillment according to levels of CRP.

evident among both genders and ethnic groups, suggesting that high levels of family assistance is linked to greater risk for the later development of CVD even among relatively healthy adolescents.

Yet as compared to adolescents who engaged in the same level of family assistance, those who obtained a greater sense of role fulfillment from the act of assistance had significantly lower levels of sIL-6r and CRP. This finding highlights the importance of the meaning that adolescents place upon providing help to parents and siblings in their daily lives and is consistent with other research that suggests that deriving a sense of purpose and meaning about a difficult or stressful life circumstance can be beneficial and may mitigate potentially detrimental effects upon health (Bower et al., 2003). Continued research should focus on the ways in which adolescents find meaning in providing assistance to their families, with particular attention to the factors that prevent some teenagers from getting a sense of role fulfillment from the activity.

It is possible that the latter group of adolescents find themselves in more difficult home environments or are caring for family members who are incapacitated due to disabilities, all of which have been linked to elevated inflammation in adulthood (Kiecolt-Glaser et al., 2003; Taylor et al., 2006). Rich information on the home environment was unavailable in the current study and future work should focus on more detailed assessments of the family context in which assistance occurs. For example, the economic conditions that give rise to family assistance are likely to be more complex than our measure of parental education can capture (Burton, 2007). Family income, work instability, and economic pressure (i.e., difficulty making ends meet) are more process-oriented measure of socioeconomic conditions that could be more directly relevant to the link between family assistance and inflammation. Similarly, the health practices and health behaviors of adolescents and their families such as smoking and alcohol use should be addressed more thoroughly than was done in the present study given their relevance for inflammation and their associations with socioeconomic status and the family environment.

The non-experimental nature of the data does not allow for definitively arguing for the causal effect of family assistance on inflammation. Recent experimental studies, however, have found a link between stress and inflammation (Steptoe et al., 2007) and our longitudinal analyses controlling for earlier levels of family assistance rule out the possibility that the results were due to other unmeasured characteristics of the adolescents that would be linked to higher levels of family assistance. Nevertheless, multiple measurements of both family assistance and inflammation across time would allow us to better examine the directionality of the association across time.

An important limitation of the study is the time interval between the measurements of family assistance and inflammation, which varied between individuals. Yet analyses indicated that the association between assistance and inflammation remained even after controlling for this interval, and that the association with CRP actually was stronger for those with a longer time interval. The results suggest that the potential impact of family assistance upon inflammation can go beyond the immediate experience and last several months. We do not know, however, whether the participants in our study continued to engage in similar levels of family assistance during the measurement interval, and the large correlation between the 10th grade and 12th grade reports of family assistance suggests a substantial amount of continuity. The time interval might also have contributed to the stronger associations that were found for sIL-6r and CRP as compared to IL-6. Elevated levels of sIL-6r and CRP are thought to be relatively stable downstream indicators of aggregated IL-6 levels over time (Robles et al., 2005). As such, one would not expect to observe elevated levels of sIl-6r and CRP immediately after the occurrence of daily interpersonal stress. In contrast, as a more variable indicator of inflammation, IL-6 is likely to be influenced more contemporaneously by activities such as family assistance and may have shown a stronger association if it was measured closer to the period that family assistance was assessed.

An additional drawback of the study was in the variable measurement of inflammation across different times of the day. IL-6 has been shown to have a diurnal rhythm and it is possible that the smaller magnitude of the association with IL-6 was due to greater measurement error. Yet this error was likely to be small given that most of the diurnal change in the level of IL-6 occurs in the very late afternoon and evening hours, and the modal time of measurement in this study (1:30 pm) was during a period of relative stability in IL-6 levels (Vgontzas et al., 1999). The existence of a diurnal rhythm for sIL-6r and CRP is currently unclear given the limited amount of research. Two published studies reported no diurnal rhythm in either sIL-6r or CRP (Meier-Ewert et al., 2001; Dugué and Leppänen, 1998). One study did report a diurnal rhythm in CRP, but it was very subtle and only accounted for 0.3% of the variance in CRP (Rudnicka et al., 2007). The diurnal rhythm was represented by two nadirs at 9:00 am and 9:00 pm, with no variation during the afternoon hours when we collected the blood samples in our study. In addition, our analyses indicated that the time of measurement during the day did not influence the observed associations. Nevertheless, multiple measurements of inflammation across the day in future studies will provide a more comprehensive understanding of the links between family assistance and different aspects of inflammatory

activity (e.g., total amount across the day, daily slope, morning vs. evening levels).

The relatively small sample size was a limitation that should be rectified in future studies in order to provide the statistical power necessary to explore the role of additional potential explanatory factors as well as the interaction between family assistance and individual characteristics such as gender and ethnicity. Finally, because the occurrence of acute illness and the timing and content of meals before the blood draws were not assessed in this study, the potential role of these factors in raising levels of inflammation could not be examined.

The findings of the current study are consistent with a converging body of both experimental and non-experimental evidence that stress can lead to elevated levels of inflammation, which in turn can place individuals at risk for the later development of CVD (Steptoe et al., 2007). The current study suggests that elevated levels of family assistance during the teenage years could be one such factor that contributes to such risk, and more detailed work with larger and more diverse samples would help to determine the pervasiveness and potential variability in the impact of this significant, yet understudied aspect of adolescents' daily lives.

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