Effects of Housing Relocation on Immunocompetence and Psychosocial Functioning in Older Adults

Susan K. Lutgendorf,¹ Toni Tripp Reimer,² John H. Harvey,¹ Glenn Marks,¹ Sue-Young Hong,¹ Stephen L. Hillis,³ and David M. Lubaroff⁴

¹Department of Psychology, ²College of Nursing, ³Department of Statistics and Actuarial Science, and ⁴Departments of Urology and Microbiology, University of Iowa, Iowa City.

Background. The psychological and physical response to moderate life stressors among older adults has not been well characterized. This research examines effects of voluntary housing relocation on distress and immune function in healthy older adults as a model for studying the effects of moderate life stress.

Methods. Thirty older adults moving to congregate living facilities were assessed 1 month premove, 2 weeks postmove, and 3 months postmove. Twenty-eight nonmoving control subjects were assessed at similar time points. Subjects completed psychosocial questionnaires and had early morning blood draws in their homes. Blood samples were assayed for natural killer cell cytotoxicity (NKCC), interleukin-6 (IL-6), and IgG antibody titters to the Epstein Barr virus (EBV) viral capsid antigen.

Results. Movers demonstrated decreased vigor and elevated thought intrusion 1 month premove and 2 weeks postmove. By the 3-month follow-up, vigor increased, and intrusion decreased to levels commensurate with the controls. Averaged across all time points, movers showed lower NKCC than controls; however, post-hoc analyses indicate that by the 3-month follow-up time point, these differences were no longer significant. There were no differences between groups in IL-6 or in EBV antibody titters. Independent of the effects of group, higher levels of vigor were associated with greater NKCC at all assessments and with lower EBV titters at 2 weeks postmove.

Conclusions. Findings suggest that in general, healthy older adults recover well psychologically from moderate, temporary life stressors such as moving. Whereas movers showed generally lower NKCC than controls, IL-6 and EBV antibody titters appeared not to be strongly affected by the stress of moving.

The process of psychological and physical adaptation to moderate or temporary life stressors among older adults has not been well characterized. This represents a critical gap in the knowledge of healthy aging. The present research utilizes the common life stressor of voluntary housing relocation to examine the effects of moderate life stress among healthy older adults.

Relocation to congregate living facilities is a naturalistic stressor of considerable importance to the expanding population of older Americans. In the last 20 years the development of a variety of housing options for older adults, including planned congregate housing and retirement centers, has increased greatly (1–3). Relocation is commonly conceptualized as a stressful event in the life of older adults (4) because it is frequently accompanied by major losses, such as changes in possessions, social support systems, self-perception, and mobility (5–6). Early research in this area, primarily involving involuntary relocation of older adults between institutions, revealed striking increases in mortality and morbidity postrelocation (7–9). However, studies of voluntary relocation among seniors have demonstrated increased stress (5,10) but overall maintenance of health and quality of life following the move (11–13). Factors such as controllability, predictability, and interpretation of relocation as a challenge rather than as a threat have been noted among the determinants of the individual’s response to relocation (11,12,14). Because even a voluntary move may involve a variety of challenges and uncertainties (15), we have conceptualized voluntary housing relocation as typically a moderately challenging but temporary life stressor.

Successful adaptation to life stressors such as relocation requires the ability to come to terms with such changes and their implications. A model of the stress response describes rumination (or intrusive thinking) as an aspect of the individual’s attempts to come to terms with the stressor (16). However, high levels of thought intrusion may interfere with adaptive resolution of the stressor and may contribute to anxiety, depression, and somatic symptoms (16–19).

Immunosenescence

Older adults are thought to be particularly vulnerable to the health effects of life stressors because of age-related alterations in immunocompetence (20,21). With age comes disregulation of the normal processes controlling synthesis of interleukin-6 (IL-6) (22,23), a multifunctional cytokine playing a critical role in many cellular processes (24). Elevated levels of IL-6 are particularly noteworthy because of possible contribution to pathogenesis of lymphoma, osteoporosis, and Alzheimer’s disease (23–25). Decreased natural killer cell cytotoxicity (NKCC) has been reported in older adults (26,27), although reports of unchanged and increased NKCC in older adults have also been documented (28–30). Natural killer (NK) cells are thought to play an important role in resistance to viruses and tumor surveillance.
(31), factors particularly relevant for elderly patients because as major causes of mortality include viral infections and tumors (32,33). Antibody titers to Epstein Barr virus (EBV) have also shown sensitivity to stressful life changes in older adults (34,35). Elevated antibody titers to this latent herpesvirus are thought to provide an indirect measure of competency of the cellular immune system (36,37).

**Stressor Effects on Immune Functioning in Older Adults**

Among elderly caregivers of Alzheimer’s patients, immune impairments including decreased NKCC (38), decreased NK response to stimulatory cytokines (39), poorer response to influenza vaccine (40), elevated levels of IL-6 (41), and higher antibody titers to EBV (34–36) have been demonstrated. Impairments in NKCC among caregivers have been documented long beyond the time when the spouse had either died or been placed in residential care (39). Such findings suggest that older adults may not only show concurrent immune vulnerability to stressful events but may also have a delayed or compromised recovery following chronic stress. Little is known, however, about immune response to moderate life stressors among older adults.

The present study examined the effect of voluntary housing relocation on psychosocial factors and three measures of immunity in a sample of healthy, independently living older adults. We hypothesized that older adults who are moving would experience elevated distress and less vigor premove and immediately postmove and that these factors would return to the levels of controls by 3 months postmove. We also hypothesized that movers would show decrements in measures of immune function at the premove and postmove assessments, but by 3-month follow-up, immune parameters would approximate those of controls. Finally, we hypothesized that independent of group, higher distress would be associated with greater immunocompromise and that greater vigor would be associated with less immunocompromise.

**METHODS**

The study employed a prospective longitudinal quasi-experimental design with natural assignment to moving and nonmoving groups compared at three time points. Because 1 month before moving is thought to be the most stressful time in the anticipatory period (42), assessments were made at 1 month premove, at 2 weeks postmove, and at 3 months postmove (follow-up). Control subjects were seen at equivalent time points.

**Sample Characteristics**

Movers were recruited from waiting lists of community-based congregate living facilities, and controls were recruited from senior centers and from newspaper advertisements. The final sample was composed of 30 movers and 28 controls aged 65 to 89 years (see Appendix, Note 1). Exclusion criteria included (i) corticosteroid use within 3 months, (ii) chemotherapy or radiation within 5 years, (iii) diseases affecting immune function (see Appendix, Note 2), (iv) infectious disease within 2 weeks of study entry, (v) serious illness requiring hospitalization or extended bed rest in the past 3 months, (vi) cognitive impairments, (vii) bereavement within 6 months, and (viii) Alzheimer’s caregiving. Demographics are summarized in Table 1.

**Instruments**

The Profile of Mood States short form (43,44) assesses mood over the past week using endorsements of 37 mood adjectives. In this study we examined vigor (alpha = .91) and a negative mood composite (alpha = .92) summing all negative mood subscales (anxiety, depression, anger, fatigue, and confusion).

The Impact of Event scale (IES) (17) measures intrusive thoughts related to a specified stressor. Items include “I had waves of strong feelings about it,” and “I thought about it when I didn’t have to.” Movers endorsed IES items regarding their thoughts about moving over the past week. Controls completed the scale regarding a significant stressor over the past 7 days. A score of 0 indicated no such stressor.

The Health Review checklist (45) was used to assess self-reported illness episodes experienced during the 6-week period before study entry. This scale is highly concordant (77%) with physician diagnoses (46). A revised form adapted for infectious illness episodes and normed for use by older adults was used in this study (47).

Movers rated several questions regarding moving factors (i.e., factors contributing to the decision to move). These included two items assessing “controllability”: (i) to what extent they had chosen the move themselves, and (ii) to what extent they had decided to move while still in control of such decisions. These items were rated on a 5-point Likert scale.

The Life Events Scale (48), a modified 18-item form that measures stressful occurrences during the past month, was used to control for stressors other than moving.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Movers (n = 30)</th>
<th>Nonmovers (n = 28)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (M, SD)</td>
<td>78.80 (5.73)</td>
<td>76.85 (7.13)</td>
</tr>
<tr>
<td></td>
<td>(range, 67–89 y)</td>
<td>(range, 65–89 y)</td>
</tr>
<tr>
<td>Gender</td>
<td>40.0% male, 60.0% female</td>
<td>39.3% male, 62.0% female</td>
</tr>
<tr>
<td>Education (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than high school</td>
<td>0.0</td>
<td>10.7</td>
</tr>
<tr>
<td>High school graduate</td>
<td>10.0</td>
<td>10.7</td>
</tr>
<tr>
<td>Trade school/some college</td>
<td>23.3</td>
<td>35.7</td>
</tr>
<tr>
<td>College graduate</td>
<td>50.0</td>
<td>28.5</td>
</tr>
<tr>
<td>Postgraduate degree</td>
<td>16.6</td>
<td>14.3</td>
</tr>
<tr>
<td>Relationship Status (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Married</td>
<td>60.0</td>
<td>67.8</td>
</tr>
<tr>
<td>Widowed</td>
<td>40.0</td>
<td>25</td>
</tr>
<tr>
<td>Living with partner</td>
<td>0.0</td>
<td>7.1</td>
</tr>
<tr>
<td>Income ($)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;$5,000–$10,000</td>
<td>0.0</td>
<td>18.5</td>
</tr>
<tr>
<td>$10,000–$20,000</td>
<td>10.7</td>
<td>22.2</td>
</tr>
<tr>
<td>$20,000–$30,000</td>
<td>28.5</td>
<td>14.8</td>
</tr>
<tr>
<td>$30,000–$40,000</td>
<td>42.8</td>
<td>14.8</td>
</tr>
<tr>
<td>$40,000–$50,000</td>
<td>10.7</td>
<td>11.1</td>
</tr>
<tr>
<td>&gt;$50,000</td>
<td>6.6</td>
<td>18.5</td>
</tr>
</tbody>
</table>
For demographics and biophysical variables, subjects indicated extent of exercise, sleep, smoking, and intake of alcohol or coffee over the 7 days before assessments to establish equivalence on variables that may affect tests of immune function (49). Demographic information was assessed at study entry.

**Physiological Variables**

Immunologic measures chosen for the proposed study have previously demonstrated alterations with aging (23,26,27,36) and with stress (34,35,40,41).

**Cytolytic activity of NK cells.**—Fresh peripheral blood mononuclear cells were isolated by centrifugation on a Histopaque gradient (specific gravity 1.077) and tested for cytolytic activity against the NK-sensitive K562 cells and the NK-resistant, lymphocyte activated killer cell-sensitive ZKBL target cells in a standard 4-hour separated blood $^{51}$Cr-release assay as reported previously (50). A laboratory control was used with each assay to monitor for interassay variability. Results were expressed as percent specific lysis at a given E:T ratio calculated from the formula

\[
\text{Percent specific lysis} = \frac{\text{CPM sample} - \text{CPM spontaneous}}{\text{CPM maximum} - \text{CPM spontaneous}} \times 100
\]

NKCC was reported in percent lysis at the 50:1, 25:1, 12.5:1, 6.25:1, and 3.125:1 effector-to-target-cell ratios. For a parsimonious representation of NK activity, the mean of the percent lysis of the five E:T ratios was used in analyses (see Appendix, Note 3).

**Interleukin-6.**—Detection of IL-6 in plasma was performed by an enzyme-linked immunosorbent assay using a standard kit (High Sensitivity IL-6 Quantikine Kit; R&D Diagnostics, Minneapolis, MN), with measurements performed according to the manufacturer’s instructions and results interpolated from the standard reference curve provided with the kit.

**Epstein Barr virus.**—Samples were measured for IgG antibody titer to the EBV viral capsid antigen (EBV-VCA) using an indirect fluorescent antibody assay with reagents supplied as kits (#37184, Organon Teknika, Durham, NC), according to the manufacturer’s instructions. The highest dilution of serum able to demonstrate immunofluorescent-positive cells determined the antibody titers to EBV-VCA.

**Plasma albumin.**—Plasma albumin was assessed to control for nutritional status. Assays used an endpoint method based on a modification of the Doumas brom cresol green dye-binding reaction (51).

**Procedures**

Following screening, psychosocial and health assessments were administered by a trained research assistant and a project nurse in the subject’s home. Prior to administration of questionnaires at each assessment, a 35-ml sample of peripheral venous blood was collected in heparin vacutainer tubes (Becton Dickinson, Rutherford, NJ). Samples were kept at room temperature until processing. Blood samples were gathered between 8 and 11 AM to minimize circadian variability and were processed immediately upon arrival at the laboratory. Plasma samples were separated, aliquoted, and frozen at $-40^\circ$C.

**Statistical analyses.**—Distributions of all variables were examined for outliers and nonnormality. Logarithmic transformations were used to normalize IL-6 and EBV data. Chi-square tests and one-way analyses of variance (ANOVAs) were used to establish equivalence at baseline between movers and controls on demographic and biophysical variables. Split-plot repeated measures multivariate ANOVAs with time as the within-subjects factor and group as the between-subjects factor were used (i) to test for main effects of group and interaction effects, (ii) to test for group differences at each time point, and (iii) to examine within-group changes responsible for significant interactions. Parallel multiple regressions were performed at each time point to examine whether psychosocial variables contributed a unique effect to immune variables over and above the effect of moving group.

**RESULTS**

All movers had chosen to relocate voluntarily and were moving to congregate living facilities following waiting list periods ranging from several months to over 2 years. Seventy percent of movers indicated that they decided to relocate now because they wanted to move while still in control of the move. There were no significant associations relating perceived controllability with mood or immune outcomes (all $p > .18$).

**Control Variables**

Movers and controls were compared on possible confounding variables at study entry. No significant differences between groups were found with respect to gender, living arrangements, marital status, chronic medical conditions, income, or education (all $p > .18$). One-way ANOVAs revealed no significant differences between groups in age, alcohol use, coffee consumption, hours of sleep, or negative life events (all $p > .25$). Mann-Whitney-Wilcoxon rank sum tests indicated no significant differences between groups in exercise frequency or illness episodes prior to study entry (all $p > .17$).

Three movers and five controls reported the use of hormone replacement therapy (HRT), and two movers and five controls used beta-blockers. There were no significant differences at any time point in NKCC or IL-6 between users and nonusers of beta-blockers ($p > .23$) or HRT ($p > .12$ for NK; $p > .08$ for IL-6). Participants using beta-blockers had significantly higher EBV titers, and those using HRT had, at least at one time point, lower titers than nonusers of these medications ($p < .05$); thus, all analyses for EBV used beta-blockers and HRT as covariates. Albumin levels for all subjects were within normal ranges (52).

**Effects of Moving on Vigor and Distress**

Means and standard deviations of psychosocial and immune measures are shown in Table 2. The omnibus test
showed a significant multivariate Group × Time interaction effect for vigor \([F(2,54) = 3.75, p = .03]\) and a trend toward a main effect for group, \([F(1,55) = 3.16, p = .08]\). One month before relocation, movers reported significantly less vigor than their nonmoving counterparts \([F(1,55) = 6.03, p = .01]\). At 2 weeks postmove, movers still reported significantly lower levels of vigor than controls \([F(1,55) = 4.19, p < .05]\); by follow-up their vigor was commensurate with that of controls \((p = .77)\). The increase in vigor between study entry and follow-up was significant among movers \([F(1,55) = 5.40, p = .024]\), whereas there were no significant changes in vigor among controls \((p > .12)\) (see Figure 1). For total negative mood, there was neither a main effect for group \([F(1,55) = .18, p = .67]\) nor a significant Group × Time interaction \([F(2,54) = .91, p = .40]\).

For intrusion, the omnibus test showed no main effect for group \((p = .11)\), but it did show a significant Group × Time interaction effect \([F(2,54) = 11.22, p < .001]\). At study entry, movers reported significantly more intrusive ideation than controls \([F(1,55) = 12.67, p < .001]\). Movers showed sustained elevations in intrusion at 2 weeks compared with controls \([F(1,55) = 5.65, p = .02]\), but by follow-up, intrusion of movers did not differ significantly from that of controls \([F(1,55) = 2.73, p = .10]\). The decrease in intrusion over the course of the study was significant for movers \([F(1,55) = 27.47, p < .001]\) but not for controls \([F(1,55) = .74, p = .39]\).

**Effect of Moving on Immune Measures**

For NKCC, the omnibus test showed a significant main effect for group \([F(1,46) = 7.27, p = .01]\), indicating that

### Table 2. Means (SD) for Psychosocial and Immune Measures in Older Adult Movers and Controls

<table>
<thead>
<tr>
<th>Variable</th>
<th>Premove Movers</th>
<th>Controls</th>
<th>Postmove Movers</th>
<th>Controls</th>
<th>Follow-up Movers</th>
<th>Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td>POMS vigor</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9.07 (5.70)**</td>
<td>12.78 (5.69)</td>
<td>8.60 (5.28)*</td>
<td>11.41 (5.06)</td>
<td>11.00 (5.53)</td>
<td>11.41 (5.25)</td>
</tr>
<tr>
<td>POMS negative mood</td>
<td>15.70 (14.49)</td>
<td>15.29 (11.36)</td>
<td>15.93 (15.64)</td>
<td>14.85 (11.74)</td>
<td>11.90 (18.09)</td>
<td>17.37 (18.08)</td>
</tr>
<tr>
<td>IES intrusion</td>
<td>11.33 (9.06)**</td>
<td>5.74 (7.03)</td>
<td>8.23 (8.39)*</td>
<td>4.26 (5.65)</td>
<td>4.10 (6.96)</td>
<td>8.33 (10.19)</td>
</tr>
<tr>
<td>NK activity (mean % lysis)</td>
<td>20.43 (10.39)*</td>
<td>30.19 (16.53)</td>
<td>20.70 (10.89)**</td>
<td>35.69 (18.93)</td>
<td>23.94 (15.23)</td>
<td>29.08 (15.77)</td>
</tr>
<tr>
<td>IL-6 pg/ml</td>
<td>3.30 (3.09)</td>
<td>2.69 (3.07)</td>
<td>3.53 (3.19)</td>
<td>2.77 (2.95)</td>
<td>3.90 (3.09)</td>
<td>3.60 (3.02)</td>
</tr>
<tr>
<td>EBV-VCA</td>
<td>1143.70</td>
<td>1026.67</td>
<td>1173.33</td>
<td>913.33</td>
<td>1120.00</td>
<td>1026.67</td>
</tr>
<tr>
<td>Antibody titer</td>
<td>(766.95)</td>
<td>(793.60)</td>
<td>(859.34)</td>
<td>(708.47)</td>
<td>(638.46)</td>
<td>(772.27)</td>
</tr>
</tbody>
</table>

*Significantly different from controls at this time point, \(p < .05\).  
**Significantly different from controls at this time point, \(p = .01\).
movers demonstrated lower NKCC than controls averaged across all time points. The Group × Time interaction effect for NKCC was not significant \( [F(2,45) = 2.52, p = .09] \). Exploratory analyses indicated that the moving group had significantly lower levels of NKCC than controls across all time points \( [F(1,46) = 10.76, p < .01] \), but not at postmove \( (p = .26) \) (see Figure 2 and Appendix, Note 4). Although levels of IL-6 were higher in movers than in controls at all assessments, there were no significant main \( [F(1,53) = 1.88, p = .17] \) or interaction effects for IL-6 \( [F(2,52) = 1.88, p = .17] \). Similarly, there were no significant main \( [F(1,47) = 1.50, p = .23] \) or interaction \( [F(2,48) = .01, p = .98] \) effects for EBV.

**Interrelationships Among Psychosocial and Immune Variables**

To evaluate the unique contribution of psychosocial variables to immune outcomes after controlling for effects of group, a series of cross-sectional multiple regressions was performed. Separate regression equations were computed for each immune criterion variable at each time point, using the following hierarchical steps. Step 1: covariates (beta-blockers, HRT) were stepped and retained if significant at \( p < .05 \); Step 2: the moving group (dummy coded) was entered into the equation; Step 3: vigor, negative mood, and intrusion were entered into the equation. At all time points, vigor significantly predicted concurrent NKCC \( (\beta = .29, t = 2.05, p < .05) \) at study entry; \( \beta = .37, t = 2.77, p = .005 \) postmove; and \( \beta = .37, t = 2.64, p < .05 \) at follow-up. These equations indicate that after controlling for the effects of group, greater vigor was associated with higher NKCC. Vigor marginally predicted EBV titers pre-move \( (\beta = -.27, t = -1.83, p = .07) \) and significantly predicted EBV postmove \( (\beta = -.42, t = -3.07, p = .004) \), with greater vigor associated with lower EBV titers. Distress variables did not predict EBV or NKCC. There were no significant relationships between psychosocial variables and IL-6 (see Tables 3 and 4 and Figure 3).

**DISCUSSION**

In this longitudinal study of older adults voluntarily undergoing the life stressor of housing relocation, relationships among psychological factors and immunocompetence were examined prospectively with respect to a known stressor with a predictable time course and relatively uniform recovery period. Movers demonstrated elevated thought intrusion and decreased vigor 1 month before the move compared with their nonmoving counterparts. These indicators of distress were still evident 2 weeks postmove but returned to levels of controls by 3 months postmove. It is possible that the relative controllability and the temporary nature of the relocation process contributed to the recovery evidenced in the present sample.

Movers in general showed lower NKCC than controls across the course of the study. At the first two assessments, the NKCC of movers was about two thirds that of controls. By follow-up, NKCC of movers was still reduced but had reached almost 75% of control levels. The Group × Time interaction for NKCC was not significant, suggesting that the pattern of change did not differ between the two groups over time. However, exploratory post-hoc testing as well as visual inspection of the data showed that, although movers had lower NKCC than controls at the first two time points, they did not differ at the follow-up time point. Whereas this may

**Figure 2. Means (and SE) for natural killer (NK) cell cytotoxicity (mean percent lysis) in moving and nonmoving older adults at premove, postmove, and follow-up.**
be interpreted as suggesting some degree of NK recovery at the 3-month follow-up, in the absence of a significant Group × Time interaction, such an interpretation should be made with caution. The observed impairment in NKCC among movers is consistent with stress-related alterations in levels of NKCC observed in other samples of older adults (34,35,38,53). As NK cells have an important role in protection against infectious illnesses and tumor metastases, these findings suggest that an increased level of vulnerability may be present among movers; however, the clinical significance of the NKCC reductions observed in this study are not known. Sustained NKCC decrements have been reported in former Alzheimer’s caregivers several years following the patient’s death (39). In the present sample, because NKCC differences between movers and controls existed at study entry, it is difficult to ascertain to what extent recovery had occurred by follow-up. Whether with greater time passage the NKCC of movers would more closely approximate that of controls is a question for future study.

The absence of group differences in EBV-VCA titers was surprising in light of findings among older adults (34–36) and in meta-analytic studies regarding the responsiveness of this measure to acute and chronic stress (54). Because antibody titers to latent herpesviruses rise with age (36), there may have been a ceiling effect in this population, making it difficult for stress to affect antibody titers when they were already quite high. Alternately, more severe stress, such as that experienced by Alzheimer’s caregivers, may be necessary to effect alterations in EBV titers among elders.

The association of vigor with both greater NKCC and lower EBV-VCA titers in the sample as a whole was consistent with our expectations and suggests a relationship between the vitality and positive mood tapped by the vigor scale and these measures of immune function in older adults. The consistency of the association of vigor with NKCC at each assessment points to the strength of this relationship. Although the relationship of vigor with EBV antibody titers was less robust, this finding suggests that in older adults, vitality and positive mood may also be associated with more effective cellular control of latent EBV. EBV antibody titers are thought to be an indirect reflection of overall cellular immune competence (36,37). Future re-

| Table 3. Regression Models Predicting Natural Killer Cell Cytotoxicity (NKCC) Outcomes |
|-----------------------------|-----------------------------|-----------------------------|
| **Variables**               | **NKCC at Premove**         | **NKCC at Postmove**        | **NKCC at Follow-up**      |
|                            | **R** | **Beta at Entry** | **Beta in Final Model** | **ΔR²** | **R** | **Beta at Entry** | **Beta in Final Model** | **ΔR²** | **R** | **Beta at Entry** | **Beta in Final Model** | **ΔR²** |
| Step 1                      | .33   | -.33*          | .11*                      | .44     | -.43** | -.37**         | .19**                  | .17     | -.17 | -.23           | .17                 |
| Group                       | -.28 | .28            |                          | -.28    | .12    | .37**          | .37*                   | .14     | .05  | -.24           |                    |
| Step 2                      | .46   | .29*           | .09                       | .56     | .37**  | -.03           | .08                   | .26     | .07  |                   |                    |
| Vigor                       | .29   |                |                           |         | .37**  |                |                       |         |      |                   |                    |
| Negative mood               | .07   |                |                           |         | -.03   |                |                       |         |      |                   |                    |
| Intrusion                   | .14   |                |                           |         | .05    |                |                       |         |      |                   |                    |

Notes: Significance of models: Equation 1: F(4,43) = 2.82, p < .05; Equation 2: F(4,43) = 4.91, p < .005; Equation 3: F(4,43) = 2.66, p < .05.

*p < .05; **p < .01.

† Standardized Beta.

<table>
<thead>
<tr>
<th>Table 4. Regression Models Predicting Epstein Barr Virus Viral Capsid Antigen (EBV-VCA) Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Variables</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Covariates</td>
</tr>
<tr>
<td>HRT</td>
</tr>
<tr>
<td>Beta-blockers</td>
</tr>
<tr>
<td>Step 2</td>
</tr>
<tr>
<td>Group</td>
</tr>
<tr>
<td>Vigor</td>
</tr>
<tr>
<td>Negative mood</td>
</tr>
<tr>
<td>Intrusion</td>
</tr>
</tbody>
</table>

Notes: Significance of models: Equation 1: F(4,46) = 1.28, p = .29; Equation 2: F(5,45) = 1.90, p = .11; Equation 3: F(5,45) = 1.78, p = .14. HRT = hormone replacement therapy.

*p = .07; **p < .05; ***p < .01.

† Standardized Beta.
search examining relationships of vigor with more specific tests of cellular immune function are needed to more fully understand the implications of this finding.

Although levels of IL-6 were elevated in movers compared with controls at all time points, these elevations did not reach significance. We have previously observed elevated IL-6 in older female Alzheimer’s caregivers compared with women movers and controls from the present sample (41). One interpretation of the present findings is that for substantial elevations in IL-6 to occur, chronic and severe levels of stress, such as those seen among caregivers, may be necessary and that the levels of stress involved in moving may not be sufficient to affect IL-6. Alternately, the power in this sample may have been too low to detect differences between groups in IL-6; with a larger sample size, group differences in IL-6 may emerge more clearly.

This study has a number of limitations. On the basis of practical considerations for obtaining a representative sample of older adults, we utilized a strategy eliminating only the most severe medical confounds, utilizing exclusion factors used in previous immune studies of older adults (34,35,39). As a result, all potential confounds contributing to the observed outcomes may not have been assessed.

Because movers and controls differed at study entry, there was no true baseline for NKCC. The interpretation most consistent with the links between chronic stress and NKCC reported in other studies is that the lower NKCC observed at study entry was a reflection of the life stress these individuals were facing. The most likely alternative hypothesis is that there was a systematic difference in health between the two groups at study entry that may have contributed to the NK differences. However, there were no differences observed between movers and controls in either chronic or acute illnesses at study entry. This would suggest that the difference in baseline NK activity was not due to a systematic difference in health factors between the two groups. It is possible, though less likely, that some undetermined third factor in individuals planning to move was responsible for this finding. For example, factors contributing to the decision to move, such as perception of personal vulnerability, proximity of family, or denial of future needs may have differentiated movers from controls. Thus, observed group differences may reflect pre-existing differences between groups as well as effects of the actual stress of moving. Future work may benefit from a comparison group of individuals wait listed for congregate living facilities to control for these factors.

It should be noted that there is a good deal of variability inherent in the NK assay, in part because of the sensitivity of this measure to stress and to other state influences and also because of the use of fresh target cells with each assay. However, the existence of a main effect for group in this measure, as well as a relationship between vigor and NK activity, over and above interassay variability, points to the strength of these findings.

We have no direct measure assessing how stressful the older adults in this study found their move; therefore, inferences about the stressful nature of the move come from the elevated levels of intrusion and lower levels of vigor reported by movers at the first two assessments.

Participants in this study were Caucasian and predominantly upper middle class. These factors, combined with the relatively small sample size, suggest that generalization to older adults of other ethnicities and differing socioeconomic levels be done with caution. Among elders who are less healthy, more economically disadvantaged, or moving to...
less desirable locations, the course of psychological or immune adaptation might be more impaired.

In summary, these findings suggest that healthy older adults, although demonstrating temporary psychological vulnerability to a moderate life stressor, generally showed good psychological recovery during a 3-month follow-up period. Overall findings indicated reduced NKCC in movers compared with control subjects, whereas IL-6 and EBV appeared not to be strongly affected by the stress of moving.

Acknowledgments

This study was funded in part by the National Institute on Aging Interdisciplinary Research Training Program on Aging (T32 AG00214) and by the National Institute of Nursing Research through a grant entitled Gerontological Nursing Interventions Research Center (P30NR03979). We acknowledge the assistance of Mike Andrews, Laura McKeel, Megan LaVelle, Susan Longley, Karin Larsen, Erin Ashby, Carol Hartman, and Lavon Yeggy, who contributed to various aspects of data collection, to Nancy Goldsmith for administrative assistance, and to David Evans for statistical assistance.

Address correspondence to Susan Lutgendorf, PhD, Department of Psychology, E11 Seashore Hall, University of Iowa, Iowa City, IA 52242. E-mail: susan-lutgendorf@uiowa.edu

References

Appendix

Notes

1. Two subjects (one mover and one control) had difficulty with venous access in the first session, and therefore gave no blood samples at any time point. One control was not available for assessment after the first time point due to ill health. Two controls were EBV negative, and two movers had too little plasma for analysis; they were not included in analyses of EBV data. NK measures were unavailable for 8 samples due to technical problems, such as difficulties with target cell viability and hemolysis of blood. All of these samples belonged to movers.

2. These included cancer, active rheumatoid arthritis, Acquired Immune Deficiency Syndrome, myasthenia gravis, lupus, multiple sclerosis, scleroderma, and polymyositis.

3. Percent lysis rather than lytic units was used as an outcome measure because models for calculating lytic unit values utilize assumptions and calculations that can result in inaccurate model-predicted cytotoxicity (55).

4. The same pattern of findings existed at each individual E:T ratio as well.