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Social Integration and Pulmonary Function in the Elderly

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Objective: This study sought to determine whether social integration, defined as number of social roles, is associated with better pulmonary function in the elderly and which roles are associated with greatest benefit. It also examined pathways that connect social integration to better lung health. ***Methods:*** High functioning men ($n = 518$) and women ($n = 629$) ages 70–79 were recruited as part of the MacArthur Study of Successful Aging, and data were collected on social roles as well as pulmonary function as assessed by peak expiratory flow rate (PEFR). Multiple regressions predicting PEFR from the number of social roles controlled for age, sex, race, education, weight, and height. Physiological, behavioral, social, and psychological factors were tested as mediators of the association between the number of social roles and PEFR. ***Results:*** More social roles were associated with better PEFR. Analysis of specific roles indicated that marriage was the strongest positive correlate of PEFR. However, greater numbers of roles were also associated with better PEFR independent of marriage. Being a relative or friend were each also individually associated with better PEFR. Even so, greater numbers of social roles were associated with better PEFR independent of relative and friend. The data were consistent with greater happiness, not smoking, and more physical activity acting as pathways linking the number of roles to PEFR. ***Conclusions:*** Number of social roles is an important correlate of healthy lung function in the elderly. This association may be driven by healthier behaviors and greater feelings of well-being.

Keywords: catecholamines, happiness, lung function, pulmonary function, social integration, social roles

Social integration (SI)—the total number of social roles one participates in (Brissette, Cohen, & Seeman, 2000)—has been associated with better mental and physical health, including decreased morbidity and mortality (reviewed by Berkman, 1995; Helgeson, Cohen, & Fritz, 1998; Holt-Lunstad, Smith, & Layton, 2010; Seeman, 1996). However, it is still not clear what behavioral and physiological processes explain the link between number of social roles and better health. Also unclear is whether there are specific social roles that matter most and whether the potency of specific roles depends on where one is in the life course.

Here we address these questions by examining the association between SI and pulmonary function—an important marker of general physical health—in a healthy elderly sample. Pulmonary function is an indication of the efficiency of the lungs to inhale and exhale. Poor lung function is an independent risk factor for mortality (Cook et al., 1991; Knuiman et al., 1999) and a wide range of diseases associated with aging such as diabetes (Engström et al., 2003), cardiovascular disease (Engström et al., 2003; Sin, Wu & Man, 2005), dementia (e.g.,Albert et al., 1995; Emery, Finkel, & Pedersen, 2012), and depression (Giltay, Nissinen, Giampaoli, Zitman, and Kromhout, 2010).

Although the association of SI and pulmonary function has not been studied, that the respiratory system has repeatedly been found to be sensitive to social and psychological stimuli (Kotses, Westlund & Creer, 1987; Lehrer, Isenberg & Hochron, 1993; Ritz, Steptoe, DeWilde & Costa, 2000; Ritz & Steptoe, 2000; Ritz, George, & Dahme, 2000) suggests that such a relationship is possible. For example, experimental studies with asthmatic patients have shown changes in lung function in response to laboratory mood induction, facial expression manipulation, and exposure to laboratory stressors (see Ritz, George & Dahme, 2000 for review).

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There are several possible pathways linking SI to health. They include the following: 1) health practices such as smoking, alcohol consumption, physical activity, and sleep (e.g., Cohen, 1988; Berkman & Breslow, 1983; House, Landis, & Umberson, 1988; Umberson, 1987); 2) biological pathways such as function of the hypothalamic pituitary adrenal (HPA) axis and sympathetic nervous system, and immune and inflammatory responses (e.g., Cacioppo, Hawkley, & Bernston, 2003; Cohen, 1988, 2004; House et al., 1988; Uchino, Cacioppo, & Kiecolt-Glaser, 1996; Uchino, 2004); and 3) psychological processes, especially feelings of purpose, control, identity, self-acceptance, affect regulation, and coping (e.g., Cohen, 1988, 2004; Thoits, 1986, 1995; Uchino, 2004). Health practices may link to lung function through smoking and physical activity, with smoking leading to faster pulmonary decline and increased physical activity being associated with slower decline in lung function (U.S. Department of Health & Human Services, 1984; Pelkonen et al., 2003). Biological factors may operate by way of neuroendocrine reactivity and sympathetic nervous system (SNS) activation. Both have been found to be sensitive to social environments in both animals and humans (Seeman & McEwen, 1996). Moreover, both have been associated with decreased lung function, HPA-axis dysregulation, by means of lower levels of cortisol (Sparrow, O'Connor, Rosner, DeMolles, & Weiss, 1993), and prolonged SNS activation indicated by increased norepinephrine and epinephrine (Wright, Rodriguez, & Cohen, 1998). Decreased levels of cortisol may lead to prolonged airway inflammation attributable to the lack of instigation of cortisol's downstream anti-inflammatory mechanisms (e.g., reduction of histamine release), and SNS activation may alter lung function through nerve pathways that directly connect the SNS to lung tissue (Barnes, 1986).

Few studies, however, have investigated the relationship between psychological factors and pulmonary function in healthy individuals. Prospective data tying higher levels of optimism and better pulmonary function have been reported (Kubzansky et al., 2002). High hostility has also been associated with poorer pulmonary function in both cross-sectional (Jackson, Kubzansky, Cohen, Jacobs, & Wright, 2007) and prospective (Kubzansky et al., 2006) studies.

Studies examining the presence or absence of specific social roles in the context of health do not typically compare roles with one another. Roles that have been studied in isolation include marriage, frequently tested as a possible health predictor (e.g., Holt-Lunstad, Birmingham, & Jones, 2008; Robles & Kane, 2012), being a parent (Sneed, Cohen, Turner, & Doyle, 2012; Umberson, 1987), being employed (e.g., Repetti, Matthews, & Waldron, 1989), and being a volunteer (e.g., Lum & Lightfoot, 2005; Sneed & Cohen, in press). An exception is the analysis of participants ranging from 18 to 69 years of age from the Alameda County Study (Berkman & Breslow, 1983; Berkman & Syme, 1979) that found that both an aggregate measure based primarily on number of social roles, as well as all five individual roles they assessed (marriage, friendship, relatives, church, or social group members) were individually associated with lower risk for mortality. This work suggests the possibility that these roles make similar contributions to SI, and thus are interchangeable in terms of aggregate scores, when it comes to health benefits.

One issue not addressed in these data from the Alameda County Study was whether there was a difference in the importance of specific roles for elderly adults in contrast to other age groups. The social networks of the elderly are known to shrink in size, with declines being limited to relatively peripheral ties (Carstensen, 1992) and the remaining network including people who offer the greatest emotional rewards (Carstensen, 1998). In fact, in another analysis of the Alameda County Study (Seeman, Kaplan, Knudsen, Cohen, & Guralnik, 1987), it was found that among participants aged 60 and older, close friends and/or relatives played a larger role in predicting 17-year mortality than they did in those younger than 60. These data provide initial evidence for the hypothesis that more intimate ties (e.g., marriage, close friends and family members) are more important constituents of SI's potential influence on the health of older adults than more peripheral roles.

This study seeks to determine the importance of SI—the number of social roles one endorses—for pulmonary function, in a healthy elderly population. In addition, analyses are conducted to determine the importance of each social role within SI, to ascertain the interchangeability of roles with regard to their influence on pulmonary function. Possible behavioral, biological, social, and psychological mediators between SI and lung function will also be explored.

Method

Participants

Data were from the MacArthur Research Network on Successful Aging Community Study, a three-site longitudinal study of 603 men and 749 women aged 70–79 years. The sample was limited to high functioning participants based on 6 health criteria: 1) no reported disability as measured by the Activities of Daily Living Scale (Katz, Ford, Moskowitz, Jackson, & Jaffe, 1963), 2) no more than one reported limitation on a measure of range of motion and mobility disability (Nagi, 1976; Rosow & Breslau, 1966), 3) ability to hold semitandem balance for at least 10 seconds, 4) ability to stand from a chair at least five times in 20 seconds, 5) a score of 6 or more on the Short Portable Mental Status Questionnaire (Pfeiffer, 1975), and 6) remembering 3 or more items from a 6-item short story (Pfeiffer,1975). Participants were excluded from the present analyses if missing data on the outcome measure, SI, or any of the standard control variables (see below). The remaining sample included 1147 with a mean age of 74.3 (SD = 2.7). Fifty-five percent were women, 48% were married, 19% were non-white, and 19% were employed. The median income was $12,500, and the median years of education was 11.

Procedure

Baseline data collection was completed between 1988 and 1989. It included a 90-min face-to-face interview covering detailed assessments of social and psychological characteristics, physical and cognitive performance, and health status. Lung function was assessed during the interview. A urine sample was also collected on the night after the interview for hormone assessments.

Measures

Peak expiratory flow. The interview included three measurements of peak expiratory flow rate (PEFR) with a mini-Wright

peak flow meter (Armstrong Industries, North Brook, IL). The participant was asked to blow as hard and fast as possible into the instrument while in a standing position. The score used for the analyses was the mean (L/min) of the three measurements.

Social integration. The measure of SI consisted of the number of social roles (types of social relationships) in which participants reported active participation. The social roles that were assessed included spouse, parent, other relative, friend, church member, club member, volunteer, and employee. The participant was considered a parent, other relative, or friend if they reported seeing a child, other relative, or friend, respectively, at least once a month. They were considered a church or club member if they reported attending the church or club at least once a month. They were considered a spouse or employee if they reported being currently married or employed and a volunteer if they volunteered for an organization during the previous year.

Control variables. Information was collected on a range of variables that might account for both more roles and better pulmonary function. These included age, race (white vs. nonwhite), sex, education (in years), weight, and height. Height and weight were used, as opposed to body mass index, because they are more commonly included in linear models to explain variance in PEFR (Mishra et al., 2013).

Potential mediators. The potential mediators of effects of SI on PEFR include a range of health behavior, physiological, social, and psychological variables. Health behaviors assessed included smoking, alcohol consumption, and physical activity. Smoking status was determined using a dichotomous variable where 0 = nonsmoker or former smoker and 1 = current smoker. Alcohol use was assessed by self-reported ounces per month of beer, wine, and hard liquor. Physical activity was measured using the Yale Physical Activity Survey (YPAS; Dipietro, Caspersen, Ostfeld, & Nadel, 1993) which asked about frequency and intensity of work- and leisure-related activity. Physical activity scores were derived by multiplying frequency by intensity and summing over all activities. The measure yields a score between 0 and 4, with 0 indicating inactive and 4 indicating engagement in both moderate and strenuous activity.

The physiological variables assessed included cortisol, epinephrine (EPI), and norepinephrine (NE) assayed in a 12-hour urine sample collected the night after the interview. Pilot data had indicated that 12- and 24-hour urine collections were highly correlated (for EPI $r = .95$, NE $r = .80$, cortisol $r = .81$, all $ps < .001$), providing justification for the 12-hour (8 p.m. to 8 a.m.) sampling frame. These data were adjusted for creatinine concentration, to account for daily variability in urine volume. Samples were sent to Nichols Laboratories (San Juan Capistrano, CA), and determinations were made by high performance liquid chromatography, with interassay variation for cortisol being 1% in low range and 8% in high. Interassay variation for catecholamines was 8–9% regardless of range. Systolic and diastolic resting blood pressure were based on the average of the second and third of three seated readings.

Measures of potential social mediators included assessments of social support (frequency of receipt of emotional and instrumental support) and negative social interactions (frequency of interactions involving conflict or excessive demands among social ties) (Seeman, Bruce, & McAvay, 1996). The psychological measures included assessments of depression, somatization, anxiety, mastery, self-efficacy, life satisfaction, and happiness. Depression, somatization, and anxiety were measured using the Hopkins Symptoms Checklist (Derogatis, Lipman, & Rickels, 1973), mastery using the Pearlin Scale (Pearlin & Schooler, 1978), and self-efficacy via a scale developed by Rodin and McAvay (1992). Life satisfaction and happiness were measured with brief questionnaires (Campbell, Converse, & Rodgers, 1976; Karasek & Thorell, 1990).

Statistical approach. Phi correlations were used to assess the associations between individual social roles. Linear regression models were used to assess the associations between SI and lung function. Lung function was regressed on number of social roles controlling for age, sex, education, race, weight, and height. A set of separate mediational analyses were then performed where in each regression we added a single hypothesized mediator and assessed the extent of reduction in variability accounted for by SI. We performed Sobel Tests (Sobel, 1982) to determine whether the reduction in variability was statistically significant. Finally, all of the potential mediators were entered into a single equation to evaluate their total effect on the magnitude of the association between SI and pulmonary function. Two-tailed tests of significance were used. The same procedures were used to examine associations of individual social roles with pulmonary function. Here each role was dichotomized using dummy codes (1 = *participant-endorsed role*, 0 = *participant did not endorse role*).

Results

The normal range for PEFR is between 60 and 800 L/min and varies with height and weight. The mean PEFR in this sample was 426.94 L/min ($SD = 116.78$) for men and 298.73 ($SD = 86.62$) for women. This is comparable with a similar study of healthy men (55 years and over) and women (65 years and over) in which the mean PEFR was 480 ($SD = 100$) L/min for men and 320 ($SD = 85$) L/min for women (Nunn & Gregg, 1989).

The mean number of social roles was 4.36 ($SD = 1.48$) out of 8. The percentage of people endorsing each social role is shown in Figure 1. Age, sex, education, race, weight, and height were controlled in all regression analyses because they were correlated with PEFR ($rs = -.12, -.53, .17, -.10, .32, .22$, respectively with all $ps < .001$).

Correlations Between Roles

Phi correlations among the 8 social roles are presented in Table 1. As apparent from the table, marriage was positively correlated

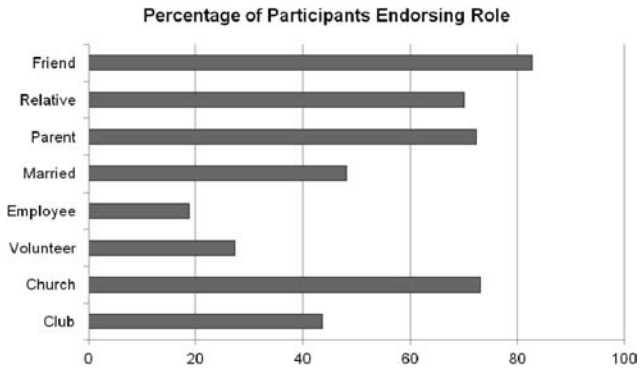

Figure 1. Percentage of participants endorsing each social role.

Table 1
Phi - Correlations Among Social Roles

Role	Club member	Church member	Volunteer	Employee	Spouse	Parent	Relative	Friend
Church member	.199***	—	—	—	—	—	—	—
Volunteer	.394***	.153***	—	—	—	—	—	—
Employee	.005	.063*	.043	—	—	—	—	—
Spouse	−.092**	−.025	−.001	.105***	—	—	—	—
Parent	−.091**	−.053†	−.103***	.043	.183***	—	—	—
Relative	.015	.126***	−.020	.016	−.007	.021	—	—
Friend	.184***	.156***	.155***	−.017	−.091**	.011	.130***	—
Total Social Roles	.522***	.509***	.533***	.394***	.369***	.317***	.418***	.471***

† $p < .10$. * $p < .05$. ** $p < .01$. *** $p < .001$.

with being a parent and with being employed, but was negatively related with belonging to clubs and having friends. Being a relative was only associated with being a church member. On the other hand, roles positively correlating with being a friend included club membership, church membership, and volunteering, indicating that friendship had greater overlap with a cluster of less intimate roles.

Social Roles and Lung Function

First, total number of social roles was entered along with controls. Greater numbers of social roles were associated with better PEFR ($\beta = .11$, $p < .001$; without controls $\beta = .17$, $p < .001$; see Figure 2). Next, to determine which specific social roles predicted PEFR, we fit separate regressions for each of the 8 roles. The results of these analyses are reported in Table 2. As apparent from the table, being married, being a relative, and being a friend were each associated with better lung function. No other roles were related to PEFR.

Marriage has been shown to be a potent predictor of better health (including the largest regression coefficient here), and might itself, as a component of SI, account for an association between the total social roles index and PEFR. Consequently, we created a second social role composite measure *without* the marriage variable. Entered in a regression separately, a greater number of social roles (not including marriage) was associated with better PEFR ($\beta = .083$, $p = .001$). When marriage and the composite of the other social roles were entered together, both were significant independent predictors of better PEFR ($\beta = .110$, $p < .001$ and $\beta = .079$, $p < .001$, respectively). Greater numbers of social roles were also associated with better PEFR when the roles of relative and friend were excluded from the total social roles score ($\beta = .090$, $p < .001$) as well as when all three (marriage, relative and friend) were excluded ($\beta = .055$, $p = .025$).

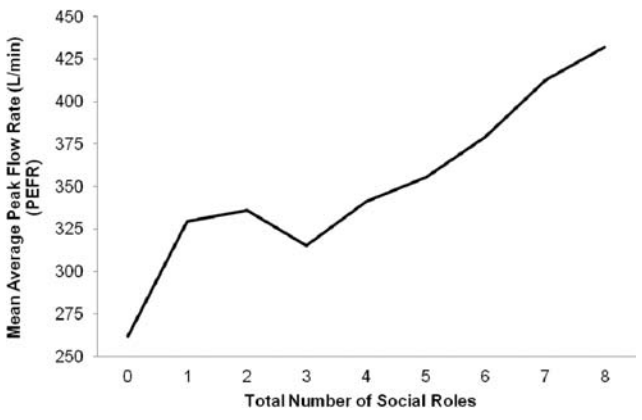

Figure 2. Linear association between total number of social roles and mean average peak expiratory flow rate (PEFR).

Independence of Social Roles

We were interested in which roles were independent predictors of PEFR. Because marriage was such a strong predictor of PEFR, we began by testing the association of the other roles that predicted PEFR individually controlling for marriage along with the standard covariates. We ran separate regressions entering friend, or relative, or the aggregate of the remaining roles (employee, parent, club member, church member, and volunteer). The relative role still predicted PEFR ($\beta = .057$, $p = .019$) as did the friend role ($\beta = .074$, $p = .002$), and the composite of the remaining social roles ($\beta = .048$, $p = .049$). We then fit a single model including marriage, friend, relative, and the total of remaining social roles. When entered together, marriage was the strongest predictor of PEFR independent of the other roles ($\beta = .115$, $p < .001$, $\Delta R^2 = .011$), followed by the friend role ($\beta = .062$, $p = .013$, $\Delta R^2 = .003$). Relative ($\beta = .047$, $p = .052$, $\Delta R^2 = .002$) approached significance, whereas the composite of all other social roles was not significant ($\beta = .033$, $p = .191$, $\Delta R^2 = .001$).

Table 2
Regression Coefficients for Association Between Individual Social Roles and PEFR

	B	*SE*	β	*t*	*p*
Club member	7.12	6.03	.030	1.18	.237
Church member	5.04	6.77	.019	.74	.457
Volunteer	9.24	6.71	.034	1.38	.169
Employee	9.47	7.59	.031	1.25	.213
Spouse	27.24	6.35	.114	4.29	.001
Parent	7.80	6.68	.029	1.17	.243
Relative	15.17	6.39	.058	2.38	.018
Friend	21.23	7.75	.067	2.74	.006

Note. Results from 8 separate analyses, all analyses control for age, sex, education, race, height, and weight.

Mediators of Social Integration and Pulmonary Function

Exploratory mediation analyses were conducted to determine whether any of the assessed psychological, social, physiological, or health behaviors might mediate the effect of the number of social roles on PEFR. To be considered a possible mediator, a variable had to be related to both SI and PEFR, and had to also substantially reduce the association of the social variable with PEFR (MacKinnon, Fairchild, & Fritz, 2007). Sample sizes in these analyses vary some as a result of missing data (see below).

A number of the potential mediators were associated with both greater number of social roles and better lung function ($p < .05$). Behavioral/physiological variables meeting both criteria included lower EPI, not being a smoker, and greater overall physical activity, whereas psychological variables included higher levels of mastery, efficacy, life satisfaction, and happiness. Alcohol intake, cortisol, measures of blood pressure, and measures of social support did not meet these criteria. Of those variables associated with both SI and lung function, significant mediators based on Sobel tests are presented here. Happiness emerged as the strongest psychological variable ($\Delta\beta = -13\%$, Sobel $t = 3.17$, $p < .001$, $n = 1139$). In terms of behavioral/physiological variables, level of physical activity and smoking both reduced the relationship between SI and PEFR (physical activity, $\Delta\beta = -27\%$, Sobel $t = 3.65$, $p < .001$, $n = 937$; smoking, $\Delta\beta = -19\%$, Sobel $t = 3.55$, $p < .001$, $n = 1096$). When including all of the above discussed significant mediators in a single regression equation, the relationship between SI and PEFR was reduced 44% ($n = 892$). Table 3 displays mean happiness and physical activity scores and smoking status distribution separately for those who did and did not endorse engaging in each of the 8 social roles.

Discussion

This study is the first to explore the connections between SI and lung function. Results indicate that greater numbers of social roles are associated with higher levels of lung function (see Figure 2), and that plausible pathways connecting the variables include physical activity, not smoking, and greater happiness.

Social Roles and Lung Function

When examining individual roles, we found that marriage was the strongest predictor of lung function. This is consistent with research showing that married people have lower levels of morbidity and mortality (Kiecolt-Glaser & Newton, 2001). Marriage confers many benefits, including increased levels of socioeconomic status via dual incomes, which can lead to increased access to health care and decreased medical costs. Spouses may also be constant monitors of their partner's behavior and provide encouragement in health and well-being goals (Tucker & Anders, 2001; Umberson, 1992). Finally, the presence of an intimate and close relationship that is consistently available may provide stability that leads to better well-being and to social support in the face of adversity (Cohen & Wills, 1985).

We then asked whether the association of number of social roles with PEFR was attributable to the individual role of marriage.

Table 3
Mean Happiness and Physical Activity Scores and Smoking Status Distribution by Whether Participants Endorsed Each of the 8 Social Roles

	Happiness		Physical activity		Smoker status	
	n	Mean (*SD*)[a]	*n*	Mean (*SD*)[a]	*n*	%[b]
Club member						
No	642	13.93 (2.52)	507	2.77 (.60)	613	17.8
Yes	497	14.49 (2.28)***	430	2.77 (.62)	483	13.3*
Church member						
No	305	13.91 (2.56)	223	2.84 (.57)	286	21.7
Yes	834	14.28 (2.38)*	714	2.74 (.62)*	810	13.7***
Volunteer						
No	827	13.94 (2.49)	670	2.71 (.61)	795	17.6
Yes	312	14.80 (2.16)***	267	2.90 (.59)***	301	11.0**
Employee						
No	927	14.07 (2.46)	760	2.74 (.62)	893	15.3
Yes	212	14.63 (2.27)**	177	2.89 (.56)**	203	17.7
Married						
No	590	13.94 (2.48)	487	2.66 (.65)	571	16.8
Yes	549	14.43 (2.36)***	450	2.88 (.54)***	525	14.7
Parent						
No	316	14.01 (2.42)	258	2.70 (.64)	313	16.6
Yes	823	14.24 (2.44)	679	2.79 (.60)*	783	15.5
Relative						
No	338	14.18 (2.55)	275	2.75 (.62)	331	17.8
Yes	801	14.18 (2.38)	662	2.78 (.61)	765	14.9
Friend						
No	195	13.46 (2.77)	146	2.74 (.53)	187	21.9
Yes	944	14.33 (2.33)***	791	2.77 (.63)	909	14.5*

[a] Significant difference based on independent sample *t* tests. [b] Significant difference based on χ^2 analysis. * $p < .05$. ** $p < .01$. *** $p < .001$.

Although marriage is associated with employment and parenthood, it is also associated with not belonging to clubs or being a friend. When marriage is removed from the calculation of number of social roles, number of roles still predicts lung function, and does so independently of marriage. Overall, these data indicate that marriage does not account for the association of SI and lung function, but merely contributes to it.

We also addressed what other roles contributed to the relation between SI and lung function. There were individual associations of marriage, friends, and relatives, with increased lung functioning indicating benefits of having these roles. This is consistent with the findings discussed earlier by Seeman et al. (1987) demonstrating that close relatives and/or friends had a greater impact on 17-year mortality in those 60 and older than their younger counterparts. Although the remaining roles (employee, parent, club member, church member, and volunteer) were not individually associated with lung function, the number of these 5 roles combined was associated with lung function, indicating that they also contribute to the association of SI and PEFR. The relatively small rates of employees and volunteers may account for their not individually predicting, although parenthood and club and church membership rates were high enough to expect relationships. Possibly, these roles are less salient for this age group and more than one is required to reach a threshold of influence. Alternatively, these roles may represent less intimate relationships. In the case of parenthood, such an interpretation would need to assume that children are not close to their parents at this age. It may also be the case that parents do not have as much exposure to their adult children as they do to friends and relatives. For example, parents reported that the mean number of children they saw once a month was 2.19 ($SD = 1.48$), whereas those reporting friends saw an average of 5.83 ($SD = 7.87$) friends in a month and exposure to other relatives was reported as a mean of 3.62 ($SD = 4.29$) per month. This lack of statistical significance of social interactions with children for health in this population of American elderly has also been found in a study of the role of negative interactions in hypertension in the Health Retirement Study (Sneed & Cohen, manuscript under review). It is also important to note that the assessment of parent role (reporting having "seen" the child in the past month) may not have tapped important phone, text, e-mail, or social media interactions that can occur between parent and child. This may be of particular importance in this elderly population as their adult children may no longer be living in close proximity, making physical contact difficult or impossible.

Which are the key social roles for this population? As suggested earlier, marriage accounts for the greatest percent of variance, and friends and relatives each are also individually related to PEFR. When these three roles are entered together into the equation, all three (although at $p = .052$ for relatives) remained independently predictive. This suggests that one can account for much of the association with just these three intimate roles. However, this does not preclude the possibility that any of these roles could be replaced by correlated roles whose effects are wiped out in the regression with all roles included. In sum, this suggests that among this population of healthy 70–79 year olds, marriage, as well as other intimate relationships, are important social roles for health, whereas other roles, such as church member, volunteer, parent, and so forth also contribute as interchangeable parts of one's SI. In other words, what matters most is the diversity of roles with which the person identifies, irrespective of which specific roles are involved.

The importance of marriage, relatives, and friends may be particular to this healthy older age group, as previous studies with younger populations have found other specific roles, such as parent (Sneed et al., 2012), employee (Repetti et al., 1989), and volunteer (Lum & Lightfoot, 2005), to be important for health outcomes as well. That intimate relationships are important in this elderly sample may be a consideration when developing SI and social role–related health interventions for older healthy adults.

Social Isolation or Social Integration?

There have been two explanations for the association between SI and better health (Cohen, 2004). One is that the association is attributable to those with the lowest SI (socially isolated) being at increased risk for morbidity and mortality (e.g., House et al., 1988), presumably as a result of the stress associated with isolation. The other is that there is a graded relation with each increase in number of social roles associated with an increase in health and this continues beyond the social isolation threshold (Cohen, 2004), with benefits presumably being attributable to positive effects of greater SI on cognition, affect and physiology, and improved health practices. Figure 2 indicates that our data are consistent with the operation of both mechanisms, with the greatest difference in PEFR between the most isolated and those with a few social roles, but a positive association with PEFR apparent along the entire SI continuum.

What Mediates the Association Between Social Integration and Lung Function?

Of the psychological variables, happiness was particularly important, accounting for 14% of the association between SI and lung function. This is consistent with research showing relations between positive affect and health (Pressman & Cohen, 2005; Steptoe, Wardle, & Marmot, 2005; Davidson, Mostofsky, & Whang, 2010). Happiness could improve lung function through several pathways that are not explored in this study, including improved sleep quality, better diet, exercise, and nutrition, all which have been shown to be related to both positive affect (Pressman & Cohen, 2005) and lung function (Cooper & Phillips, 1982; Grievink, Smit, Ocke, van t'Veer, & Kromhout, 1998; Bentley et al., 2012). In addition, those with increased happiness may spend more time relaxing and more time outdoors (Smith & Baum, 2003), away from potential indoor environmental determinants of poor lung function (e.g., Moran, Strachan, Johnston, & Anderson, 1999).

That being said, behavioral measures were the strongest potential mediators of the social integration-PEFR connection, explaining 19% (smoking) and 27% (physical activity) of the variability. For physical activity, the root of this connection and the direction of causality are unclear. It may be that more social roles result in greater physical activity because social activities involve more physical activity, or because of the social pressure placed on individuals by their network members to engage in a healthy lifestyle (Lewis & Rook, 1999). Of course, there is always the possibility that physically active individuals have access to more social roles (Holt-Lunstad et al., 2010).

The fact that we found no mediational role for social support was not surprising. SI and support are generally only moderately correlated at best (Cohen & Wills, 1985). Moreover, whereas social support is thought to operate primarily by providing protection in the face of stress, SI is thought to influence health through a range of mechanisms, for example, social control, more positive and less negative emotions, greater feelings of personal control, greater self-regard, that directly (whether or not someone is experiencing stress) promote health (Berkman, Glass, Brissette, & Seeman, 2000; Cohen & Wills, 1985; Cohen, 2004). This difference may be exacerbated here because the participants in this study were quite physically and cognitively healthy and hence not experiencing any serious health events, nor likely to have experienced other major events that generally would put them at high risk for health deficits.

Conclusions

This is the first study examining the association of SI and its constituent roles with pulmonary functioning. Although this work explores a relatively unstudied question, these data are from a single time point and the analyses are cross-sectional, making the direction of causality uncertain. It is of course possible that poor pulmonary function resulted in an inability to create or maintain social relationships. However, based on the strict eligibility criteria, we believe that few, if any, of the participants had deficits in pulmonary function that would influence their ability to participate in social interactions. For example, endorsing any difficulties in breathing or history of pulmonary problems, difficulty going up and down stairs, difficulty with walking, inability to stand from a chair at least 5 times in 20 seconds, or any reported disability on the Activities of Daily Living Scale would have excluded participation in the study. Although we controlled for multiple third variables, such as age, sex, race, education, weight, and height, there is also the possibility that an unaccounted for factor might cause both changes in social networks and pulmonary function. Finally, these data are almost 25 years old. Although the methods of measuring lung function, social integration, and other variables have not changed significantly within these years, there still may be cohort effects that make these data less generalizable to today's population of 70- to 79-year-olds.

This study included an extremely healthy sample of the elderly population which may account for the broader range of social roles than reported by others studying this age group and in turn for the effectiveness of these roles in promoting health. That is, the loss of roles with aging may be attributable to a great extent to declines in health and functionality one finds in unselected samples of the elderly.

The data reported here make several contributions to the existing literature. First, they demonstrate an association between SI and an important marker of health in the elderly, such that lung function should now be considered as a potential pathway that may link SI to rates of morbidity and mortality. Second, although marital status is associated with better lung function, marriage is not a necessary component of SI to benefit health in older adults. Third, there are a set of social roles that are interchangeable in terms of their contributions to SI, with many roles serving similar functions in relation to lung health. These roles do not, however, include being a parent which is not associated with lung function in our elderly sample. Fourth, we have explored possible pathways by which SI can influence health by identifying the specific health behaviors of smoking and physical activity, along with the psychological parameter of happiness. The identification of these pathways may inform targeted interventions. Finally, this study provides evidence consistent with the hypothesis that the association between SI and health is attributable to both the negative influences of social isolation on health, as well as to the positive effects of increasing numbers of social roles.

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