

Loneliness and the Metabolic Syndrome in a Population-Based Sample of Middle-Aged and Older Adults

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Objective: This study evaluated the association between loneliness and the metabolic syndrome, which refers to a clustering of factors that have been shown to increase risk for cardiovascular disease, diabetes, stroke, and mortality. A secondary purpose was to evaluate whether age moderated the association between loneliness and the metabolic syndrome. **Design:** Participants were 52 to 79 years old, and they were drawn from a population-based survey of people 50 years of age and older living in England ($N = 3211$). They completed a self-report measure of loneliness and a nurse visit that included collection of blood pressure, blood sample, and anthropometric measures. **Main Outcome Measures:** Self-reported loneliness and the metabolic syndrome. **Results:** After controlling for demographic variables and smoking status, loneliness was significantly associated with increasing likelihood of meeting criteria for the metabolic syndrome and with the individual criterion of central obesity. The association between loneliness and the metabolic syndrome was not moderated by age. **Conclusion:** Results suggest that loneliness is associated with the metabolic syndrome. Therefore, the metabolic syndrome may be among the pathways by which loneliness increases risk of morbidity and mortality.

Keywords: loneliness, social isolation, biomarker, metabolic syndrome

Social isolation has been linked to a variety of chronic health conditions and adverse health outcomes (House, Landis, & Umberson, 1988; Seeman, 2001). There is emerging evidence that loneliness—the unpleasant and distressing subjective experience of social isolation that results, in part, from deficiencies in a person’s social relationships (Peplau & Perlman, 1982)—is also predictive of morbidity and mortality. For example, loneliness predicted mortality over a 29-month period, controlling for age, sex, chronic diseases, alcohol consumption, smoking, self-rated health, and functional limitations (Penninx et al., 1997). Loneliness is also predictive of self-rated health (e.g., Mullins, Smith, Colquitt, & Mushel, 1996) and a variety of mental and physical health outcomes (e.g., Alpass & Neville, 2003; Cacioppo, Hughes, Waite, Hawkey, & Thisted, 2006), including cardiovascular health (e.g., Orth-Gomér, Undén, & Edwards, 1988; Sorkin, Rook, & Lu, 2002). For example, higher loneliness predicted incident

coronary heart disease over 19 years of follow-up in a community sample of women (but not men), controlling for demographic, health, and other variables (Thurston & Kubzansky, 2009).

Given the association between loneliness and health, researchers have begun to search for possible biological mechanisms by which loneliness may contribute to poor health in general, and cardiovascular disease (CVD) in particular. For example, loneliness has been associated with higher peripheral resistance and lower cardiac output (Cacioppo et al., 2002; Hawkey, Bureson, Berntson, & Cacioppo, 2003). The most widely studied biological marker of CVD that has been studied as a correlate of loneliness is blood pressure, because elevated systolic and diastolic blood pressure are important risk factors for CVD (for a review, see Prospective Studies Collaboration, 2002). Loneliness was found to be associated with elevated systolic blood pressure in a convenience sample (Cacioppo et al., 2002) and in a population-based sample of people between the ages of 50 and 68 years (Hawkey, Masi, Berry, & Cacioppo, 2006); loneliness did not, however, covary with blood pressure or heart rate in a third study (Steptoe, Owen, Kunz-Ebrecht, & Brydon, 2004). Blood lipids are a second set of biological markers of CVD that have been examined as correlates of loneliness. Research has shown that CVD risk is associated with higher levels of low-density lipoprotein (LDL) cholesterol and lower levels of high-density lipoprotein (HDL) cholesterol (e.g., Sharrett et al., 2001), and higher levels of triglycerides (for a review, see Sarwar et al., 2007). Results from one study suggested that loneliness was associated with elevated levels of triglycerides; the bivariate association between loneliness and total serum and HDL cholesterol were not reported (Sorkin et al., 2002). Inflammatory markers are a third class of biological markers that have been shown to increase risk for CVD that have been studied as correlates of loneliness. For example, C-reactive protein is a serum inflammatory marker that is associated with elevated risk for CVD

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The data were made available through the United Kingdom Data Archive (UKDA). The English Longitudinal Study of Ageing (ELSA) was developed by a team of researchers based at the National Centre for Social Research, University College London, and the Institute for Fiscal Studies. The data were collected by the National Centre for Social Research. The funding is provided by the National Institute of Aging in the United States, and a consortium of United Kingdom government departments coordinated by the Office for National Statistics. The developers and funders of ELSA and the Archive do not bear any responsibility for the analyses or interpretations presented here.

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(for a review, see Danesh et al., 2004). However, loneliness did not covary with C-reactive protein in the one study that evaluated this association (McDade, Hawkey, & Cacioppo, 2006).

In summary, the pattern of results obtained from prior studies suggests that loneliness may be associated with specific biological markers of health in general and CVD in particular. However, the associations between loneliness and other biological markers for risk of CVD have yet to be examined. Specifically, prior research on loneliness and biological functioning has focused on individual biological markers. Researchers examining biological markers of risk for CVD have also identified a composite measure of biological functioning labeled the *metabolic syndrome*, which refers to a clustering of interrelated factors that have individually been shown to be associated with increased risk of CVD and diabetes (Alberti et al., 2009). Although definitions of the metabolic syndrome differ in diagnostic threshold values, the most generally accepted components of the syndrome are central obesity, dyslipidemia (elevated triglycerides and lowered HDL cholesterol), elevated blood pressure, and dysglycemia (elevated fasting glucose). Meta-analytic studies have found that in comparison with people without the syndrome, people with the metabolic syndrome are at increased risk for incident CVD, cardiovascular events, and coronary heart disease (Galassi, Reynolds, & He, 2006; Gami et al., 2007), incident diabetes mellitus (Ford, Li, & Sattar, 2008), incident stroke (Galassi et al., 2006; Li et al., 2008), and mortality (Galassi et al., 2006; Gami et al., 2007).

The primary objective of this study was to extend prior research on loneliness and biological markers of health through evaluating the association between loneliness and the metabolic syndrome, in a population-based sample of middle-aged and older adults from England. Because not all lonely individuals have CVD or other adverse health outcomes, the secondary objective of the study was to evaluate potential moderators of the association between loneliness and the metabolic syndrome. Identifying individual differences that moderate the association between loneliness and biological markers of health may have important public health implications in terms of identifying people at greatest risk for the adverse effects of loneliness. The strength of the association between loneliness and biological markers may be moderated by age, insofar as loneliness may accelerate the rate of physiological decline associated with aging (Hawkey & Cacioppo, 2007). This perspective is in keeping with theoretical models such as socio-emotional selectivity theory (Carstensen, Isaacowitz, & Charles, 1999), which posits that relationships are increasingly valued as people age and perceive increasingly greater constraints on the time that they have left to live. In support of this hypothesis, age significantly moderated the association between loneliness and systolic blood pressure in both a convenience sample (Cacioppo et al., 2002) and a population-based sample (Hawkey et al., 2006). The secondary objective of the study was to evaluate whether age moderated the association between loneliness and the metabolic syndrome.

Method

Participants

The study sample was obtained from the English Longitudinal Study of Ageing (ELSA), an ongoing longitudinal population-

based survey of individuals selected to be representative of people 50 years and older, living in private households in England (Marmot et al., 2009). The study was designed to investigate health, economic, psychological, and social experiences of community-dwelling older adults. Participants completed a face-to-face computer-assisted personal interview and a self-completion questionnaire; in Wave 2, which occurred in 2004–2005, a nurse visit was added that included collection of blood pressure, blood sample, and anthropometric measures. The current analyses were based on cross-sectional data obtained from Wave 2 from people who were core members (i.e., ≥ 50 years old at Wave 1), who completed the nurse visit and Wave 2 interview themselves (vs. requiring a proxy), and who did not have any missing data on the self-report measure of loneliness. Furthermore, because only people who were < 80 years old were asked to fast and because blood glucose was measured only in fasting samples, people > 79 years old were excluded. The final sample included 3211 people.

On the basis of weighted data, the sample was 48.2% men and participants had a mean age of 63.81 years ($SD = 7.52$). The legal marital status of the majority of participants (74.8% of the sample) was married; 4.9% were never married, 9.2% were separated or divorced, and 11.2% were widowed.

Measures

Loneliness. Loneliness was measured with the Three-Item Loneliness Scale (Hughes, Waite, Hawkey, & Cacioppo, 2004), which is based on the widely used Revised UCLA Loneliness Scale (R-UCLA; Russell, Peplau, & Cutrona, 1980). The three-item scale correlates highly ($r = .82$) with the R-UCLA and has demonstrated good internal consistency and concurrent and discriminant validity in population-based community samples (Hughes et al., 2004). The three items (How often do you feel you lack companionship? How often do you feel isolated from others? How often do you feel left out?) were rated on a 3-point scale (*hardly ever/never, some of the time, and often*). The sum of the items was used as the global measure of loneliness; this measure had good internal consistency in this sample ($\alpha = .82$).

Metabolic syndrome. Three blood pressure measurements were obtained from participants, and blood samples were taken from willing participants who had never had a fit or convulsion, had never had a clotting or bleeding disorder, or were on anticoagulants; current analyses are based on people with fasting blood samples, which were obtained with some exceptions (people who were ≥ 80 years old, diabetic, frail, or whose health was a concern to the nurse). The metabolic syndrome was defined as meeting three or more of the following criteria (Alberti et al., 2009): (a) elevated waist circumference (population- and country-specific definitions; for Europeans: ≥ 102 cm for men, ≥ 88 cm for women); (b) elevated triglycerides (≥ 150 mg/dL [1.7 mmol/L] or drug treatment); (c) reduced HDL cholesterol (< 40 mg/dL [1.0 mmol/L] for men, < 50 mg/dL [1.3 mmol/L] for women, or drug treatment); (d) elevated blood pressure ($\geq 130/85$ mmHg or drug treatment); and (e) elevated fasting glucose (≥ 100 mg/d or drug treatment).

Data Analysis

To evaluate whether loneliness was significantly associated with the metabolic syndrome, above and beyond any shared association

with demographic variables, I conducted logistic regression analyses, in which dichotomous coding of the metabolic syndrome and each of the five criteria defining the metabolic syndrome were regressed on loneliness, controlling for age, relationship status (married or cohabiting vs. everyone else), race (White or minority), gender (male or female), income (quintiles of total equivalized income for benefit units), and current smoking status (smoker or nonsmoker). Data were weighted to reduce bias arising from sample loss after Wave 1 and differential nonresponses between completion of the main interview and nurse visit and between completion of the nurse visit and giving a blood sample; for a complete description of differential response and the ELSA weighting strategy, see Scholes, Taylor, Cheshire, Cox, and Lessof (2008). Logistic regression analyses were conducted on weighted data using the Taylor series linearization methods in the SUDAAN software package (Research Triangle Institute, 2001), which is a program that incorporates the sample design into the data analysis, thus rendering acceptable standard errors of the parameter estimates. For ease of interpretation, the exponential of each regression coefficient was computed and interpreted as an odds ratio (OR); the 95% confidence interval (CI) was also computed for each coefficient.

To evaluate whether age moderated the strength of the association between loneliness and the metabolic syndrome, a Loneliness \times Age interaction term was computed and entered into the logistic regression analysis after controlling for the component terms (and the other covariates); loneliness and age were centered (i.e., mean deviated) prior to creating the interaction term (Whisman & McClelland, 2005).

Results

The mean level of loneliness on the Three-Item Loneliness Scale was 4.01 ($SD = 1.44$), with a range of 3 to 9. Means and standard deviations for each of the biological markers are presented in Table 1. Point prevalence of the metabolic syndrome was 22.2% ($SE = 0.8\%$).

Preliminary multiple regression and logistic regression analyses evaluating the bivariate associations between loneliness and demographic variables indicated greater loneliness was associated with (a) not being married or cohabiting ($B = .52, SE = .03, p < .001, OR = 1.7, 95\% CI = 1.6, 1.8$); (b) not being White ($B = .33, SE = .08, p < .001, OR = 1.4, 95\% CI = 1.2, 1.6$); (c) being female ($B = .14, SE = .03, p < .001, OR = 1.1, 95\% CI = 1.1,$

1.2); (d) lower income ($B = -.14, SE = .02, \beta = -.15, p < .001$); and (e) being a smoker ($B = .10, SE = .03, p < .01, OR = 1.1, 95\% CI = 1.0, 1.2$); the association between loneliness and age approached significance ($B = .18, SE = .10, \beta = .04, p = .06$).

Results from the logistic regression analyses, presented in Table 2, indicate that holding demographic variables and smoking status constant, loneliness was significantly associated with the metabolic syndrome. With respect to individual parameters, after controlling for demographics and smoking status, loneliness was significantly associated with elevated waist circumference; there was also a nonsignificant trend between loneliness and fasting blood glucose ($p = .07$).

With respect to the hypothesis that age would moderate the association between loneliness and the metabolic syndrome, the Loneliness \times Age interaction term was not significantly associated with the metabolic syndrome ($B = -.00, SE = .00, p = .88$), controlling for the component terms and the other covariates, indicating that age did not moderate this association. In addition, age did not moderate the association between loneliness and any of the individual parameters of the metabolic syndrome (all $ps > .35$).

Discussion

The primary finding from this population-based sample of people 52–79 years old living in England was that loneliness was significantly and positively associated with the metabolic syndrome and with the specific criterion of elevated waist circumference. The obtained odds ratio of 1:1 reported in Table 2 for the association between loneliness and the metabolic syndrome indicates that each one-unit increase in loneliness is associated with a 10% increase in the odds of a person meeting criteria for the metabolic syndrome, holding other variables constant. These results suggest that the metabolic syndrome, particularly elevated waist circumference, may be among the pathways by which loneliness increases risk for adverse health outcomes. Given the cross-sectional design of the study, it is also possible that the metabolic syndrome is predictive of subsequent loneliness, because people with the syndrome are more overweight and have more medical problems, which could contribute to a sense of greater isolation and loneliness. Longitudinal research is therefore needed to evaluate the direction of effect between loneliness and the metabolic syndrome.

The secondary purpose of this study was to evaluate whether age moderated the association between loneliness and the metabolic syndrome (i.e., whether loneliness was more strongly associated with the metabolic syndrome with increasing age). In lack of support for the hypothesized effect, age did not moderate the association between loneliness and the metabolic syndrome, which does not support the perspective that loneliness accelerates the rate of physiological decline associated with aging (Hawkey & Cacioppo, 2007), as has been found in prior studies evaluating the association between loneliness and systolic blood pressure (Hawkey et al., 2006). However, because these data are cross-sectional, it is possible that loneliness does accelerate the rate at which people cross over the threshold for metabolic syndrome criteria, but that once chronic disease is present and pharmaceutical treatments have been introduced, moderation is not observed. Consequently, longitudinal research is needed to evaluate whether lone-

Table 1
Descriptive Information for Biological Parameters Included in the Metabolic Syndrome

Parameter	Unit	Mean	Standard deviation	% meeting criterion
Waist circumference	cm	95.84	13.21	30.5
Triglycerides	mg/dL	149.24	90.11	38.2
	mmol/L	1.68	1.01	
HDL cholesterol	mg/dL	59.43	14.73	8.2
	mmol/L	1.52	0.38	
Systolic blood pressure	mm Hg	134.23	18.22	62.2
Diastolic blood pressure	mm Hg	76.10	10.63	
Fasting glucose	mg/dL	90.37	16.39	20.1

Note. HDL = high-density lipoprotein.

Table 2
 Logistic Regression Analyses Predicting Metabolic Syndrome and Its Component Criteria

Predictor	Metabolic syndrome component criteria ^a										Metabolic syndrome	
	1		2		3		4		5		OR	95% CI
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI		
Age	1.0	1.0, 1.0	1.0	1.0, 1.0	1.0	1.0, 1.0	1.1***	1.0, 1.1	1.0***	1.0, 1.0	1.0*	1.0, 1.0
Married/cohabiting	1.2	1.0, 1.5	1.0	0.8, 1.2	0.7	0.5, 1.0	0.9	0.7, 1.0	1.0	0.8, 1.3	0.9	0.7, 1.1
White	1.1	0.5, 2.4	1.5	0.8, 2.8	0.6	0.2, 1.9	1.1	0.5, 2.1	1.0	0.4, 2.2	1.2	0.5, 2.8
Male	3.9***	3.3, 4.7	1.4***	1.2, 1.6	5.5***	3.9, 7.6	1.4***	1.2, 1.6	1.6***	1.4, 2.0	3.0***	2.5, 3.6
Income	0.9**	0.9, 1.0	0.9**	0.9, 1.0	0.9	0.8, 1.0	1.0	0.9, 1.0	1.0	0.9, 1.0	0.9*	0.9, 1.0
Smoker	1.1	0.8, 1.4	1.4**	1.1, 1.7	1.4	0.9, 2.0	0.9	0.7, 1.2	1.1	0.9, 1.5	1.4**	1.1, 1.8
Loneliness	1.1***	1.0, 1.2	1.0	1.0, 1.1	1.1	1.0, 1.2	1.0	1.0, 1.1	1.1	1.0, 1.1	1.1*	1.0, 1.2

Note. OR = odds ratio; 95% CI = 95% confidence interval.

^a Criterion 1 = elevated waist circumference; Criterion 2 = elevated triglycerides; Criterion 3 = reduced high-density lipoprotein (HDL) cholesterol; Criterion 4 = elevated blood pressure; Criterion 5 = elevated fasting glucose.

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

liness accelerates the rate at which individuals are categorized as meeting criteria for each component of the metabolic syndrome.

The mean level of loneliness on the Three-Item Loneliness Scale in this sample was 4.01 ($SD = 1.44$), which is comparable with the mean of 3.89 ($SD = 1.34$) reported in the Health and Retirement Study conducted in the United States (Hughes et al., 2004). This suggests that the mean level of loneliness among middle-aged and older people is approximately the same in England and the United States.

Strengths of the study include the use of a large and representative sample of middle-aged and older adults and well-validated measures of loneliness and the metabolic syndrome. However, there are several limitations with this study that should also be considered. First, by assessing loneliness only once, chronic or dispositional loneliness cannot be separated from situational or transient loneliness. Repeated assessments of loneliness over time in a longitudinal study would allow researchers to evaluate the degree to which chronic loneliness and transient changes in loneliness predict metabolic syndrome over time. In particular, because participants in the study were all between 52 and 79 years of age or older, longitudinal research starting at earlier ages, before people develop chronic diseases, is necessary to determine whether loneliness accelerates the rate at which individuals meet criteria for the metabolic syndrome and its components. Second, a full understanding of the biological correlates of loneliness will require examining biological markers for other illnesses, in addition to markers such as the metabolic syndrome. For example, researchers have begun to examine whether loneliness is associated with neuroendocrine markers of stress and have found that loneliness is associated with elevated levels of cortisol in some studies (e.g., Cacioppo et al., 2000; Steptoe et al., 2004) but not in other studies (Hawkey et al., 2006); one study found that loneliness did not covary with other neuroendocrine markers, including individual differences in epinephrine or norepinephrine (Hawkey et al., 2006).

Although biological processes associated with loneliness was the focus of this study, a full understanding of the mechanisms by which loneliness impacts health will need to include behavioral factors such as health behaviors. For example, in comparison with

people who are not lonely, lonely individuals are more likely to be smokers (Lauder, Mummery, Jones, & Caperchione, 2006), and loneliness demonstrates both cross-sectional and prospective associations with reduced physical activity (Hawkey, Thisted, & Cacioppo, 2009). In replication of the results obtained by Lauder et al. (2006), greater loneliness was associated with elevated risk of a person being a smoker in this study. Evaluation of both biological and behavioral correlates of loneliness is likely to provide a more comprehensive understanding of the mechanisms by which loneliness increases risk of morbidity than would examination of only biological or only behavioral factors.

In summary, the results of the current study suggest that in this representative sample of midlife and older adults in England, greater loneliness was associated with greater likelihood of meeting criteria for the metabolic syndrome. In the current study and in other studies that have evaluated loneliness and biological markers of health, both loneliness and biological markers have been measured concurrently. Longitudinal research is needed therefore to evaluate the degree to which chronic loneliness and changes in loneliness over time are prospectively associated with the metabolic syndrome and other biological markers. To the extent that loneliness prospectively predicts biological functioning in general, and metabolic syndrome in particular, interventions focused on decreasing social isolation and the subjective experience of loneliness should improve biological functioning and ultimately improve health outcomes, including reducing the risk of CVD, diabetes, and stroke.

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