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Blood Pressure Levels and Longitudinal Changes in Relation to Social Network Factors

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Abstract

The aim of this study was to examine the relationship between social network variables and levels of and longitudinal changes in blood pressure in a middle-aged/older sample. The participants (50-75 years at baseline; *n*=1097) responded to questions concerning social relationships at baseline and their blood pressure (diastolic, systolic) was measured. Blood pressure levels were reassessed 5, 10, and 15 years later. Latent growth models with responses to questions concerning social relationships as predictors and basic demographic factors (age, sex) as covariates, unexpectedly indicated that a more limited social network (no close friend, few visits, little contact with friends in other ways, not living with someone, and a composite index based on all questions) was associated with significantly lower diastolic blood pressure levels. For systolic blood pressure a similar result was observed for one of the variables (lack of a close friend). In general, these effects diminished over time, as indexed by the positive relationship between several of the social variables and slope. The results were little affected by inclusion of additional covariates (e.g. measures of psychological distress, smoking/alcohol habits, and BMI) suggesting that the origins of this unexpected pattern of findings must probably be sought for in other subject-related factors, such as, for example, increased help seeking. Future studies should consider qualitative aspects (e.g. feelings of loneliness, quality of social relationships) in addition to structural aspects to provide a better understanding of these associations.

Keywords: blood pressure, social network, cross-sectional, longitudinal

Introduction

Hypertension is a common cause of diseases such as stroke, coronary heart disease, and many other cardiovascular diseases (MacMahon et al., 1990; Stokes, Kannel, Wolf, D'Agostino, & Cupples, 1989) and has been considered a leading risk factor for mortality (e.g. Ezzati et al., 2002). Furthermore, associations between blood pressure (BP) levels and cardiovascular diseases have also been found within normal BP range (Liszka, Mainous, King, Everett, & Egan, 2005; Vasan et al.,

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2001; Zhang et al., 2006). Thus, identifying factors that have the potential to reduce high BP levels are of acute interest.

In the present study we examined the potential role of social network factors for blood pressure. Social network is a term that can refer to the matrix of social relationships that individuals are connected to (Peek & Lin, 1999). Several studies suggest that engagement in social networks is beneficial for a variety of health outcomes, including subjective health (Melchior, Berkman, Niedhammer, Chea, & Goldberg, 2003; Okamoto & Tanaka, 2004), cognitive health (Lande, Kaczorowski, Auinger, Schwartz, & Weitzman, 2003; Waldstein, 1995), quality of life (García, Banegas, Pérez-Regadera, Cabrera, & Rodríguez-Artalejo, 2005), and cardiovascular health (Tay, Tan, Diener, & Gonzalez, 2013). In addition, there is some direct evidence of a relationship between limited social network and high BP (e.g. Bland Krogh, Winkelstein, & Trevisan, 1991; Gump, Polk, Kamarck, & Shiffman, 2001; Hanson, Isacsson, Janzon, Lindell, & Rastam, 1988; Redondo-Sendino, Guallar-Castillón, Banegas, & Rodríguez-Artalejose, 2005) and hypertension diagnosis (Cornwell & Waite, 2012). However, results are not univocal (see Hawkley, Thisted, Masi, & Cacioppo, 2010).

It is possible that having a large social network can reduce the risk of feeling lonely and thereby reduce levels of stress (e.g. Ong, Rothstein, & Uchino, 2012), and hence avoid negative effects on cardiovascular, endocrine, and immune systems (Sparrenberg et al., 2009; Uchino, Cacioppo, & Kiecolt-Glaser, 1996). Further, availability of, or support from network members, including family and friends, can be important for earlier disease diagnosis and management of hypertension. Individuals who have a larger social network are more likely to talk about health matters and are therefore less likely to have their BP uncontrolled (Cornwell & Waite, 2012). Finally, social interactions and social support might promote adherence to medical treatment (see DiMatteo, 2004).

Although there is some support for a link between social network and BP, a limited number of studies have investigated how social network factors relate to BP in the long term (cf. Redondo-Sendino et al., 2005). Hawkley et al. (2010), for an exception, found that loneliness at baseline, but not social network size, was associated with changes in blood pressure (systolic) over a follow-up period of 4 years.

Given the relative lack of prior longitudinal studies, the aim of present study was to investigate the role of social network as predictor of levels and long-term changes in blood pressure. More specifically, social network variables were included as predictors of levels (intercept) and changes (slope) in growth curve models involving baseline, 5-, 10-, and 15-year follow-up measurements of diastolic (DBP) and systolic (SBP) blood pressure in population-based samples of Swedish adults with a baseline age ranging from 50 to 75 years (Nilsson et al., 1997, 2004). The potential influence of a number of other factors (e.g. demographic-, health-, and lifestyle factors) were considered in the analyses.

Methods

Study Sample

Data emanated from the Betula prospective cohort study (Nilsson et al., 1997, 2004). Betula is a study of aging, cognition, and health that started in Umeå, Sweden, in 1988. The participants were selected from the population registry of Umeå municipality using stratified (age, sex) random sampling. So far, data has been collected over six test waves; 1988-90 (T1), 1993-95 (T2), 1998-2000 (T3), 2003-2005 (T4), 2008-2010 (T5), and 2013-2014 (T6). On each of these test occasions, participants were invited to two assessments, about one week apart. The first focused on health measures, the second on cognitive testing. Data from the latest test wave is still being prepared and the questions concerning social relationships were first included at T2. Hence, in the present analyses, data for the test waves T2-T5 were considered.

For T1 (1988-90), the participants were divided into ten age cohorts: 35, 40 and so forth up to 80 years of age. Each cohort consisted of 100 persons and the total number of trial participants (Sample 1) at the first test round was thus 1 000. For T2 (1993-95), the baseline of this study, the participants from S1 returned and two new samples were added: S2 (*n*=997) and S3 (*n*=966). S3 was divided into age cohorts 40, 45 and so forth up to 85, (i.e. the same age as S1 had at T2) whereas the sampling of Sample 2 started at 35. At T3 a further a sample was added; S4 starting at age 35, and at T4 sample 5 was included starting at the same age. For the purpose of this study, only the samples 1 and 3 contributing with longitudinal data over four test waves were included. The targeted age range in the present study was 50 years and older. Given that expected survival is very limited for the oldest groups (80-85 years at baseline) these were excluded. Hence, the present analyses targeted participants with a baseline age in the range from 50 to 75 years. An overview of the Betula design indicating the samples and measurement occasion included in the present study is provided in Figure 1.

Figure 1. *The Design of the Betula Study*

Sample	Age range*	T1 (1988-1990)	T2 (1993-1995)	T3 (1998-2000)	T4 (2003-2005)	T5 (2008-2010)	T6 (2013-2014)
S1	35-80	S1	S1	S1	S1	S1	S1
S2	35-80		S2	S2			
S3	40-85		S3	S3	S3	S3	S3
S4	35-90			S4			
S5	35-95				S5		
S6	25-80					S6	

*Age range at inclusion. Samples and test waves within rectangles were used in the current study. S=Sample, T=Test wave. For this study, participants from Samples 1 and 3 that were 50-75 years at baseline (T2) were included in the analyses.

Participants

In total, 1137 participants from sample 1 and 3 that were 50-75 years took part at T2 (1993-95). Among these, complete information about BP was available for 1125 participants. We further had to exclude participants with missing data on the social network variables (n=8), BMI (n=5), education (n=10), smoking (n=3), and alcohol use (n=2). Thus, the final sample consisted of 1097 participants[1].

The mean baseline age was 62.39 years (SD=11.14) and the sample included 489 men and 608 women from sample 1 (n=523), and 3 (n=574). As noted, data were available at the 5-year (for DBP, n=956; SBP, n=956), 10-year (for DBP, n=760; SBP, n=753), and 15-year (for DBP, n=534; SBP, n=535) follow-up for both samples. Baseline characteristics for the sample are provided in Table 1.

Table 1. *Baseline Characteristics for the Sample*

Charateristic	*M*	*SD*	%
Age	62.39	8.51	-
Female	-	-	55.4
Years of Education	9.58	3.83	-
BMI	26.50	3.87	-
Diabetes	-	-	5.9
Smoking	-	-	49.8
Alcohol Use	-	-	77.8
General Stress	3.14	2.00	-
Depressive Symptoms	0.88	1.20	
Do not Have a Close Friend	-	-	7.7
Do not Meet Friends Enough	-	-	13.4
Visiting/Visits less than Once a Week	-	-	25.1
Contact (Other Ways) less than Once a Week	-	-	11.9
Not Living with Someone	-	-	25.0
Social Network Index	0.83	0.92	-
Diastolic BP	85.17	9.69	-
Systolic BP	143.34	21.70	-
Medicament for Hypertension			4.4

Measures

Social Network

Information about social relationships were collected during the session involving a health assessment. The questions, that were part of a questionnaire involving other aspects of the participant's life situation, included the following: (1)

[1] There were relatively large amount of missing responses on general stress (n=60). The average value of the age group were used for these individuals.

"Do you have any really close friend whom you can contact and talk to about anything?" ("no", coded 1/"yes", coded as 0), and (2) "Do you think you see your friends and acquaintances often enough?" ("no", coded as 1, "yes" coded as 0). Participants were also asked; (3) "How often do you visit or are visited by your friends and acquaintances?" ("daily", "several times a week", "weekly", "once a week to once a month", "once a month to once a quarter", "less than once a quarter", or "never"); and (4) "How often do you have contact with your friends and acquaintances in other ways that visits?," e.g. by telephone ("daily", "several times a week", "weekly", "once a week to once a month", "once a month to once a quarter", "less than once a quarter", or "never"). For these two questions about contact frequency a dichotomous coding was used to get a sufficient number of observations for each of the response categories ("less than once a week" was coded as 1/"once a week or more", coded as 0). Information about (5) Living status was also collected. Not living with someone was coded as 1, whereas living with: wife/husband/common law spouse; children; wife/husband/common law spouse and children; other person; other person and children; sibling; or "other," was coded as 0. The dichotomization for the latter three questions has been used elsewhere (Sörman, Rönnlund, Sundström, Adolfsson, & Nilsson, 2015). Finally, a social network index were computed by summing the "risk" factors.

Blood Pressure

BP levels, which include both DBP and SBP variables, has been measured by nurses at all test waves. BP levels were measured after 5 minutes of rest in lying position. The auscultatory method was used with stethoscope and cuffs. In a few cases, where the pulse could not be heard, digital blood pressure meters were used.

Covariates

Covariates in the analyses were age, sex (man coded as 0, woman coded as 1), education (years of formal schooling), BMI, Diabetes (yes=1), Smoking (yes=1), and alcohol use (yes=1). In addition, general stress was included, based on the estimation of general stress on scale ranging from 1 (low) to 10 (high), Finally, a sum of six self-reported indicators of depressive symptoms (fatigue, anxiety, loss of appetite, dispiritedness, loneliness, sleeping problems) was used. This index correlates reasonably well with the Swedish version of the center for Epidemiologic Studies Depression Scale (Radloff, 1977).

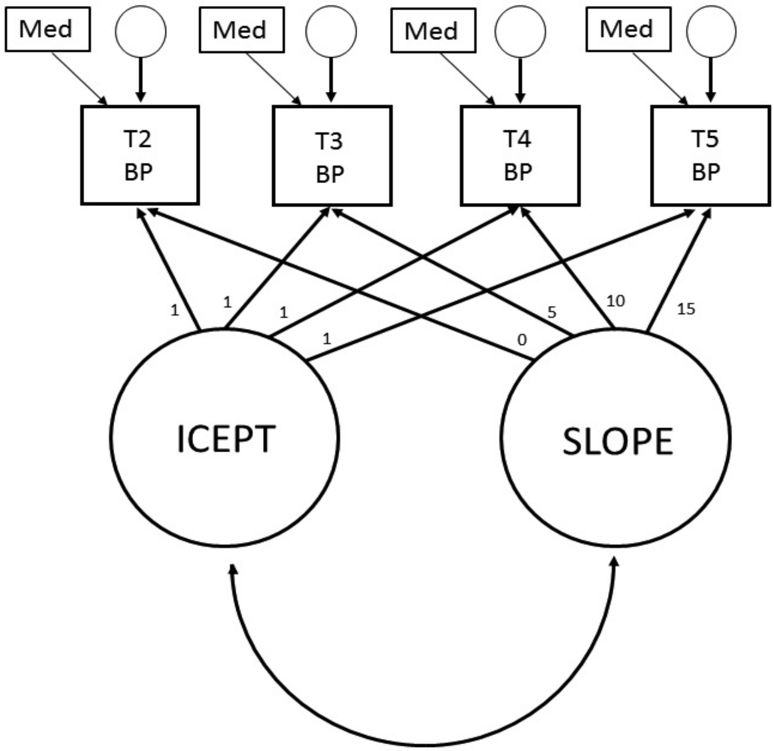
Information about having medicament related to hypertension was collected as a part of a health questionnaire administered at health assessment. The information is classified in accordance with ATC (Anatomical Therapeutic Chemical Classification System) recommended by WHO (2006). Since every participant are followed over time, and screened for high blood pressure levels, medicament for hypertension is not uncommon among participants.

Statistical Analysis

Latent growth modeling was employed to investigate whether aspects of social network could be associated with levels (i.e. the intercept), and time-related changes across the four test occasions (i.e. the slope), in diastolic and systolic blood pressure. Data were analyzed with SPSS-22 and Amos-22 using full information maximum likelihood (FIML) estimation.

First, the fit of Model A (see Figure 2), including the four time points of blood pressure data (DBP and SBP separately) was tested, controlling for medicament of hypertension. Of relevance for further analyses, this model also informs of means changes and variances for the intercept and slope and of the degree to which intercept and slope are associated.

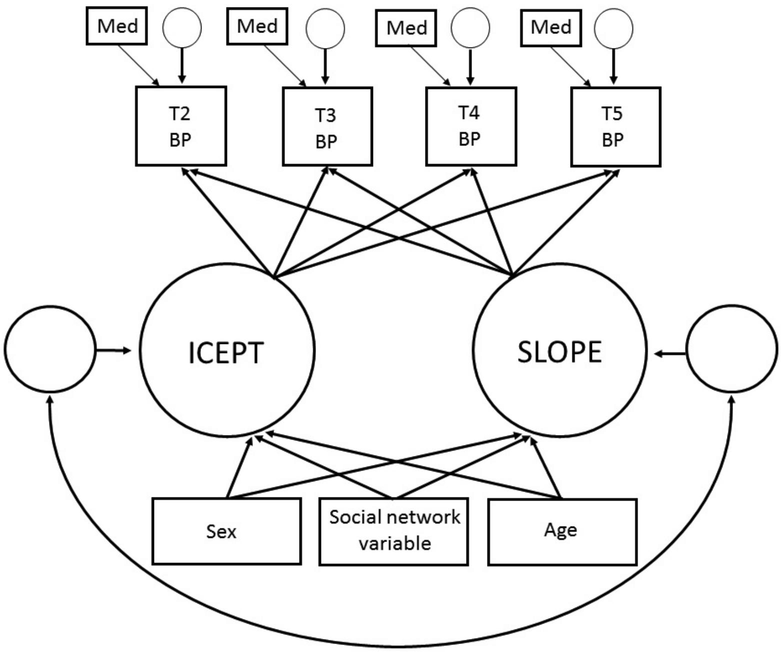
Figure 2. *Model A. The Basic Model Including Blood Pressure Data from Four Test Waves*



Note. Med=Medicament for hypertension, T2-T5=the four different test-waves, BP=Blood Pressure, ICEPT=Intercept.

Next, in Model B, aspects social network (each variable separately), age, and sex were included in the model (see Figure 3). Finally, additional covariates (gender, education, BMI, diabetes, smoking, alcohol use, stress, and depressive symptoms) were included (Model C) to see whether the effects observed in Model B persisted following control of additional factors. We used three fit indices to evaluate each model: Bentler's comparative fit index (CFI), the root-mean-square error of approximation (RMSEA), and Chi-square/*df*. To explore how each social network variable is associated with BP, standardized parameter estimates were used.

Figure 3. Model B. The Latent Growth Model Used to Investigate Aspects of Social Network as Predictors of Level and Change in Blood Pressure, Controlling for Age, Sex, and Medicament of Hypertension



Note. Med=Medicament for hypertension, T2-T5=the four different test-waves, BP=Blood Pressure, ICEPT=Intercept.

Results

Starting with results from latent growth modeling including DPB measures across the four waves with no predictors (Model A), the analysis revealed relatively good fit for some indices: CFI=.944, RMSEA=.066, and Chi-square/*df*=5.46.

Suggested thresholds for reasonable model fit are: CFI (>0.90), RMSEA (<0.08), and Chi-square/*df* (<3). Thus, indices were relatively good for CFI and RMSEA. Furthermore, means and variances for both intercept (M=85.07; S^2=55.79) and slope (M=-0.22, S^2=0.29) were significant (p<.001), the result for variances indicating that there are meaningful between-person differences both in regard to levels and changes in DPB over time. Finally, the intercept and slope showed a substantial negative correlation (r=-.59, p<.001). In conclusion, further analyses of DBP were deemed to be relevant.

For SBP, the fit for the basic model without predictors (Model A), was not fully adequate as judged by the fit indices (CFI=.880, RMSEA=.10, and Chi-square/*df*=12.25) but the mean (M=144.13) and the slope (M=0.40) was significant as were their variances, S^2=333.38, S^2=1.23, for the intercept and slope, respectively, all p<.001. As for diastolic blood pressure a negative correlation was observed between intercept and slope (r=-.72, p<.001). Based on the results, we decided to include SBP as a dependent measure in further analyses including the social relationship variables as predictors of intercept and slope.

Results from models (B) which included age and sex in addition to each of the social network variables are summarized in Table 2.

For diastolic blood pressure, several of the social network variables showed significant associations with intercepts and slope. More specifically, reports of having no close friend (β=-.080, *SE*=1.06, p=.034), visiting/visits less than once a week (β=-.085, *SE*=0.65, p=.024), having contact (other ways) less than once a week (β=-.093, *SE*=0.88, p=.016), not living with someone (β=-.091, *SE*=0.69, p=.024) and higher values on the social network index (β=-.129, *SE*=0.31, p<.001), indicating less social contacts, were all significantly related to the intercept of DBP. That is, a relative lack of a network was related to lower BP levels. For three of the variables, a reversed trend was observed with regard to slope; for close friends (β=.161, *SE*=0.11, p=.002), visiting/visits less than once a week (β=.122, *SE*=0.99, p=.020) and the social network index (β=.124, *SE*=0.47, p=.019). For systolic blood pressure, only one variable was significantly associated. Reports of not having a close friend was related to lower intercept (β=-.066, *SE*=2.19, p=.037).

In the final set of analyses, additional covariates were added to the model (Model C), including years of education, measures of stress, depressive symptoms, BMI, smoking, alcohol use, and diabetes to examine whether the predictive value of the social network variables would persist following control of additional factors. The results are summarized in Table 3.

Table 2. *Summary of the Results from Latent Growth Analyses Adjusted for Age and Sex (Model B)*

n=1097	Diastolic Blood Pressure						Systolic Blood Pressure					
	→ ICEPT			→ SLOPE			→ ICEPT			→ SLOPE		
Predictor	β	*SE*	*p*	β	*SE*	*p*	β	*SE*	*p*	β	*SE*	*p*
Do not Have a Close Friend	-.080	(1.06)	**.034**	.161	(0.11)	**.002**	-.066	(2.19)	**.037**	.058	(3.11)	.242
Do not Meet Friends Enough	.013	(.83)	.735	-.001	(1.27)	.985	-.022	(1.73)	.490	-.037	(2.45)	.453
Visiting/Visits less than Once a Week	-.085	(.65)	**.024**	.122	(.99)	**.020**	-.013	(1.35)	.681	.001	(1.91)	.986
Contact (Other Ways) less than Once a Week	-.093	(.88)	**.016**	.077	(1.35)	.145	-.015	(.1.84)	.648	-.002	(2.61)	.694
Not Living with Someone	-.091	(.69)	**.024**	-.004	(1.06)	.937	-.045	(1.44)	.186	.002	(2.04)	.962
Social Network Index	-.129	(.31)	**<.001**	.124	(.47)	**.019**	-.057	(.64)	.072	-.003	(.90)	.944

Note. ICEPT=Intercept; higher scores on predictor variables denote more limited social support.

Table 3. *Summary of Results from Latent Growth Analyses Adjusted for Age, Sex, Education, BMI, Diabetes, Smoking, Alcohol Use, Stress, and Depressive Symptoms (Model C)*

n=1097	Diastolic Blood Pressure						Systolic Blood Pressure					
	→ ICEPT			→ SLOPE			→ ICEPT			→ SLOPE		
Predictor	β	*SE*	*p*	β	*SE*	*p*	β	*SE*	*p*	β	*SE*	*p*
Do not Have a Close Friend	-.069	(1.02)	.059	.156	(1.59)	**.003**	-.059	(2.15)	.059	.051	(3.07)	.262
Do not Meet Friends Enough	.023	(.81)	.536	-.006	(1.26)	.902	-.008	(1.71)	.792	-.041	(2.44)	.414
Visiting/Visits less than Once a Week	-.065	(.63)	.077	.107	(.98)	**.041**	.006	(1.33)	.856	-.019	(1.90)	.699
Contact (Other Ways) less than Once a Week	-.077	(.86)	**.036**	.062	(1.33)	.239	-.003	(1.80)	.936	-.033	(2.58)	.507
Not Living with Someone	-.097	(.67)	**.011**	.001	(1.04)	.980	-.050	(1.41)	.132	.008	(2.01)	.885
Social Network Index	-.111	(.30)	**.003**	.110	(.46)	**.036**	-.039	(.11)	.209	-.018	(.90)	.714

Note. ICEPT=Intercept; higher scores on predictor variables denote more limited social support.

In general, the result were similar to those based on age and sex as the only covariates (Table 2). More specifically, a low frequency of contacts in other ways than visits (β=-.077, *SE*=0.86, *p*=.036), not living with someone (β=-.097, *SE*=0.67, *p*=.011), and the social index (β=-.111, *SE*=0.30, *p*=.003) were still significantly associated with lower DBP intercept. Moreover, lack of a close friend (β=.156, *SE*=1.59, *p*=.003), few visits (β=.107, *SE*=0.98, *p*=.041), and the social network index (β=.110, *SE*=0.46, *p*=.036) were positively associated with slope, as before. For SBP, the only significant association in the previous analyses (i.e. for not having a close friend with intercept) fell short of significance, but showed a similar tendency as in the previous analyses (β=-.059, *SE*=2.15, *p*=.059).

Discussion

The aim of the present study was to examine level and time-related changes in BP in relation to social network variables in sample of individuals aged 50 to 75 years at baseline.

Seemingly at odds with some prior reports that presence of social ties (e.g. Bland et al., 1991; Hanson et al., 1988; Lipowicz & Lopuszanska, 2005; Redondo-Sendino et al., 2005) is associated with lower BP levels/less risk of hypertension) our results, in particular those pertaining to diastolic blood pressure, indicate lower blood pressure levels in individuals with a smaller network. More specifically, reporting lack of a confidant, infrequent contacts with friends, not living with someone, and an index summarizing all of the questions pertaining to social network were inversely related to diastolic blood pressure level (intercept). For systolic blood pressure, the only significant association was observed for lack of a close friend (models including age and sex as covariates), but as for diastolic blood pressure, the association was consistent with a significantly lower levels (intercept) of blood pressure in those lacking this aspect of their social network. For diastolic blood pressure, three of the questions showing a significant association with intercept (Close friend, Frequency of visits, and the Composite index), showed a reversed association with slope, suggesting that the observed differences in levels (i.e. lower DBP for participants with a less extensive network) diminished over time. Similar patterns were observed for the other social network variables significantly associated with intercept, as indicated by the standardized regression weights for slope. The above mentioned results were not much affected by inclusion of additional covariates (age, sex, education, BMI, diabetes, smoking, alcohol use, stress, and depressive symptoms).

Whereas the present questions mainly targeted structural aspects of the participants' social network, it may be important to consider that qualitative, experiential aspects may be more important than structural aspects of social relationships, a pattern observed for various other health-related outcomes, such as risk for dementia (e.g. Amieva et al., 2010) and depression (Teo, Choi, & Valenstein, 2013).

Consistent with this line of reasoning, Hawkley et al. (2010) found a cumulative relationship between higher levels of loneliness at baseline and greater increases in systolic blood pressure over time (up to 4 years) in a sample of 50-68 year olds. By contrast, they found no association between a network index (marital status, number of relatives and friends, group memberships, religious group affiliation) and future increases in blood pressure. Thus, it is possible that the emotional experiences associated with social bonds are more important. In this context it is also relevant to consider the perceived quality of the relationships one has (i.e. whether or not one feels lonely).

A demonstration that quality of relationships is important to blood pressure was provided by Holt-Lundstad, Birmingham, and Jones (2008) who found that unmarried participants had lower ambulant blood pressure levels as compared with participants in low-quality marriages. Thus, low-quality relationships with spouses and friends could potentially have biased the data in favor of "loners" in the present set of data. However, if this was the case, one might have expected that adjustment of depressive symptoms and stress (presumably associated with low-quality relationships) would have eliminated the association between social relationships and blood pressure level, which it did not. In fact, more detailed analyses show that our relationship index (higher score indicating a smaller network) was positively associated with the depressive symptom score, rendering an explanation of the findings based on poor relationship quality among those with a structural "advantage" in regard to social relationships less likely.

Speculating that individuals with smaller networks, as in our study, also experience more loneliness, a remaining possibility is that they more often seek help from a physician and/or the emergency department. Hawkley et al. (2010) speculated that lonely people do this not only for medical treatment, but also for the social contact itself. Regardless, lonely people may, as a consequence, more often be prescribed with medications. Such pattern may, in part, explain the unexpected result of present study suggesting that smaller social network is associated with lower intercept of blood pressure levels.

In conclusion, we observed an unexpected pattern for diastolic blood pressure in particular, of significantly lower levels of blood pressure with a smaller size of the social network. Even though the associations were small, and diminished in magnitude over time as judged from associations with slope, they require an explanation, which was difficult to pinpoint based on the present data set. Future studies examining the relationship between social network size and health outcomes should consider qualitative aspects of social relationships, including feelings of loneliness and relationship quality and investigate the possibility that people with fewer ties actually benefit at least with regard to some aspects of health by increased help seeking.

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Niveles de presión arterial y cambios longitudinales en relación con factores de la red social: ¿Mejor juntos o por separado?

Resumen

El objetivo de este estudio fue examinar la relación entre las variables de la red social y los niveles de cambios longitudinales en la presión arterial en la muestra que consta de la gente de mediana y tercera edad. Los participantes (50-75 años; *n*=1097) respondieron a las preguntas que trataban el tema de relaciones sociales y se midió su presión arterial (diastólica, sistólica). Se volvió a valorar los niveles de presión arterial 5, 10 y 15 años después. Modelos de crecimiento latente con respuestas a las preguntas que trataban el tema de relaciones sociales (o un índice) como predictores y factores demográficos básicos (edad, sexo) como covariables, inesperadamente, indicaron que la red social más limitada (sin amigos íntimos, con pocas visitas e índice compuesto) se relacionaba con el nivel de presión arterial diastólica significativamente más baja. Para la presión arterial sistólica se confirmó el resultado similar para una de las variables (falta de amigos cercanos). En general, estos efectos disminuyeron con el tiempo, según está indexado por la relación positiva entre distintas variables sociales y la pendiente. La inclusión de covariables adicionales (p. ej. medición de trastornos psicológicos, hábitos de fumar y beber alcohol e IMC) afectaron un poco a los resultados, sugiriendo que los orígenes de este patrón de resultados inesperado probablemente los hay que buscar en los factores relacionados con el sujeto y no aquellos relacionados con el estilo de vida, como p. ej. aumento de la búsqueda de ayuda. Los futuros estudios deberían considerar aspectos cualitativos (p. ej. sentimiento de soledad, calidad de relaciones sociales), además de los aspectos estructurales, para proporcionar un entendimiento mejor de estas asociaciones.

Palabras claves: presión arterial, red social, sección transversal, sección longitudinal

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