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Social Network Characteristics and Body Mass Index in an Elderly Korean Population

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Objectives: Research has shown that obesity appears to spread through social ties. However, the association between other characteristics of social networks and obesity is unclear. This study aimed to identify the association between social network characteristics and body mass index (BMI, kg/m^2) in an elderly Korean population.

Methods: This cross-sectional study analyzed data from 657 Koreans (273 men, 384 women) aged 60 years or older who participated in the Korean Social Life, Health, and Aging Project. Network size is a count of the number of friends. Density of communication network is the number of connections in the social network reported as a fraction of the total links possible in the personal (ego-centric) network. Average frequency of communication (or meeting) measures how often network members communicate (or meet) each other. The association of each social network measure with BMI was investigated by multiple linear regression analysis.

Results: After adjusting for potential confounders, the men with lower density (<0.71) and higher network size (4-6) had the higher BMI (β=1.089, p=0.037) compared to the men with higher density (>0.83) and lower size (1-2), but not in the women (p=0.393). The lowest tertile of communication frequency was associated with higher BMI in the women (β=0.885, p=0.049), but not in the men (p=0.140).

Conclusions: Our study suggests that social network structure (network size and density) and activation (communication frequency and meeting frequency) are associated with obesity among the elderly. There may also be gender differences in this association.

Key words: Aged, Body mass index, Social support

INTRODUCTION

The study of the effects of social networks on health rose to the surface in the 1970s through pioneers such as Cassel, Cobb, and Berkman, who theorized or proved empirically that social networks could affect mortality [1-6]. After those mortality studies, several studies have reported that social networks are related to infectious diseases, such as sexually transmitted disease [7-9], tuberculosis [10], severe acute respiratory syndrome [11], and pneumonia [12]. Additionally, evidence suggests that emotions and related behaviors such as depression [13], suicide [14], and happiness [15] are also associated with social networks. Social networks affect health through several mechanisms, including the provision of social support (both perceived and actual), social influence (e.g., norms, social control), social engagement, person-to-person contact (e.g., pathogen exposure, secondhand cigarette smoke), and access to resourc-

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es (e.g., money, jobs, information) [16].

Obesity is a well-known risk factor for cardiovascular diseases [6]. Adipose tissue has been recognized as an active endocrine organ, capable of releasing many cytokines that play parts in the pathogenesis of many obesity-related diseases [17]. Social network assessment over 32 years in the Framingham Heart Study found that obesity tended to spread through intimate friends [18]. It found that an individual chances of being obese increased by 57% if she or he had a friend who also be obese. Additionally, the evidence for influence of friends on body weight comes from other studies examining the relationships between the weight of individuals and their friends [19-23]. These studies tested the relationship between the body mass index (BMI, kg/m^2) of individuals and their friends in order to address the peer effect.

It is known that obesity appears to spread through social ties. However, the association between other characteristics of social networks and obesity is unclear. Thus, we investigated whether social network characteristics such as network size, density of communication network, average frequency of communication, and average frequency of meeting were associated with BMI in an elderly Korean population.

METHODS

The Korean Social Life, Health, and Aging Project (KSHAP) conducted a social network survey and health examination from November 2011 through July 2012 among 860 community-dwelling adults aged 60 or older and their spouses living in Yangsa-myeon, Ganghwa-gun, Incheon, Korea. The institutional review board of Yonsei University approved this study (YUIRB-2011-012-01) and informed consent was obtained from all of the participants. A total of 814 people responded to the social network survey (response rate 94.7%). Potentially confounding factors were assessed as well, including age, education, smoking status (never or ever smoker), alcohol drinking status (non-drinker or drinker), depression score (Center for Epidemiologic Studies-Depression Scale, CES-D), and self-reported comorbidity (hypertension, diabetes, stroke, and arthritis). Among them, 657 participants (80.7%) were examined for height and weight in a public health center or at home. BMI was calculated from measured weight and height.

In order to collect social network data, KSHAP adopted a model similar to that of the National Social Life, Health, and Aging Project (NSHAP) [24]. On 'Social network card I' (Appendix 1), a respondent (ego) was asked questions about three types of alters: their spouse (roster A), a maximum of five people with whom the respondents discussed things that were important to them (roster B), and someone to whom the respondents felt especially close (roster C). On 'Social network card II' (Appendix 2), the respondent answered questions about the relationships among alters listed on the rosters, and this information was used to build up egocentric network variables. The difference between egocentric data and common survey questions is that egocentric questionnaires collect data on the characteristics of the persons named, that is, on the respondent's personal network. The additional network information provides some insight into personal network characteristics and their potential influence on behavior [25].

Social network characteristics are composed of network structure (network size, density, etc.) and network activation (frequency of nonvisual contact, frequency of face-to-face interaction, etc.) [16,26]. The following are the four social network measures we used.

Network Size

The egocentric network was composed of rosters A and B. Network size was simply a count of the number of alters provided in response to questions on 'Social network card I.'

Density of Communication Network

KSHAP data can be used to construct a personal (ego-centric) network density variable that reflects the extent to which someone's closest contacts are connected to one another. Density of communication network (or density) is calculated as:

$$D_e(N_i) = \frac{\sum^{e}_{j,k} d(n_j, n_k)}{(e-1)(e-2)} \quad (i \neq j \neq k)$$

Node n_j and n_k represent the adjoined nodes connected to node n_i and 'e' represents the number of adjoined nodes connected to n_i. If node n_j and n_k are connected, $d(n_j, n_k)$ becomes 1 and if not, it becomes 0. After summing and dividing by every possible number of connections between adjoined nodes, this becomes the density of the communication network. Figure 1 shows examples of various personal network densities.

Average Frequency of Communication and Meeting

Respondents were asked to rate how often they talked to

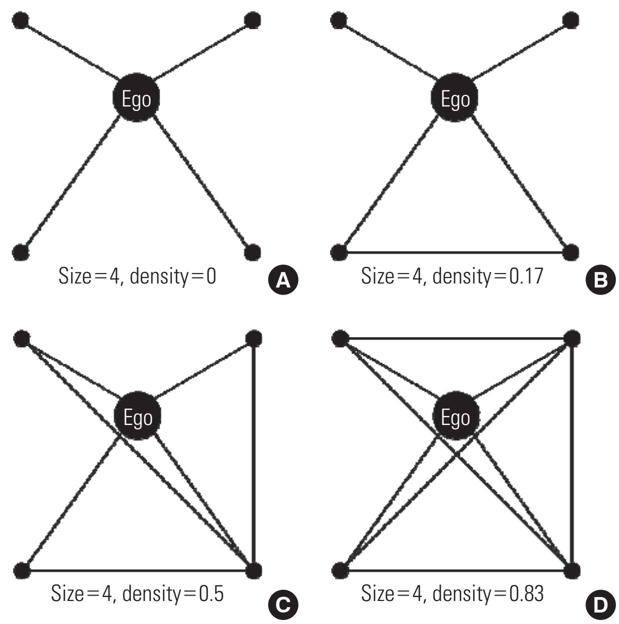

Figure 1. Personal network density. (A-D) According to the connections among friends (alters), it is possible that personal (egocentric [Ego]) social networks with same size have different kinds of densities. size, network size; density, density of communication network.

Table 1. Characteristics of the study population

Variable	Men (n=273)	Women (n=384)
Age (y)	72.79±7.07	71.73±8.14
Body mass index (kg/m²)	23.56±3.28	24.28±3.42
Depression score (CES-D)	10.30±7.67	11.84±7.92
Education (y)		
≥10	53 (19.4)	28 (7.3)
7-9	58 (21.3)	34 (8.9)
0-6	162 (59.3)	322 (83.9)
Smoker	190 (69.6)	8 (2.1)
Alcohol drinker	118 (43.2)	25 (6.5)
Comorbidity		
Hypertension	123 (45.1)	213 (55.5)
Diabetes	57 (20.9)	63 (16.4)
Stroke	14 (5.1)	16 (4.2)
Arthritis	66 (24.2)	195 (50.8)
Social network structure		
Network size	3.34±1.25	2.99±1.19
Density of communication network	0.75±0.09	0.77±0.09
Higher density (>0.83) and lower size (1-2)	62 (22.7)	139 (36.2)
Middle density (0.71-0.83) and size (3)	104 (38.1)	127 (33.1)
Lower density (<0.71) and higher size (4-6)	104 (38.1)	110 (28.6)
Unclassified	3 (1.1)	8 (2.1)
Social network activation		
Communication frequency	246.38±100.31	251.20±104.70
Upper (365)	85 (31.1)	135 (35.2)
Middle (208-364)	92 (33.7)	130 (33.8)
Lower (<208)	96 (35.2)	119 (31.0)
Meeting frequency	237.54±105.46	238.04±114.60
Upper (365)	83 (30.4)	131 (34.1)
Middle (186-364)	103 (37.7)	134 (34.9)
Lower (<186)	87 (31.9)	119 (31.0)

Values are presented as mean±standard deviation or number (%).
CES-D, Center for Epidemiologic Studies-Depression Scale.

each network member on an 8-point scale, ranging from 'everyday' to 'less than once per year'. The scores were coded by assigning the approximate number of times per year egos interacted with alters (e.g., 'everyday'=365; 'once a month'=12) and the scores were summed across all alters on roster A and roster B to obtain a measure of the overall volume of contact with network members. Then, the scores were summed and divided by the network size. The average frequency of communication (or "communication frequency") indicates how often network members communicated. The average frequency of meeting (or "meeting frequency") was likewise calculated to determine how often network members met.

Statistical Analysis

All analyses were performed separately for the men and women. To gain information on the distribution of the continuous variables (age, depression score, BMI, network size, density of communication network, and average frequency of communication and meeting), we drew a histogram and calculated the minimum, lower quartile, median, upper quartile, maximum, and mean values. In order to solve the problem of non-normal distribution, we used two approaches before multiple linear regression analyses. One was the rank transformation approach and the other was the tertile method. The Spearman correlation test was used to examine the possibility of multicollinearity among social network measures. Network size and density were strongly and inversely correlated in the men (Spearman correlation coefficient (r_s)=-0.98, $p<0.001$) and women (r_s=-0.97, $p<0.001$). We created three groups of social network structure: 'higher density (>0.83) and lower size (1-2)', 'middle density (0.71-0.83) and size (3)', and 'lower density (<0.71) and higher size (4-6)' (Appendix 3). Before the regression analysis, unclassified individuals (3 men and 8 women) were removed. For univariate analysis, the trend test

Table 2. Social network measures and body mass index: multiple linear regression

Variable	Men (n=273)						Women (n=384)					
	Model 1		Model 2		Model 3		Model 1		Model 2		Model 3	
	β	p-value	β	p-value	β	p-value	β	p-value	β	p-value	β	p-value
Social network structure												
Network size[1]	0.093	0.12	0.107	0.07	0.123	0.04	0.068	0.18	0.071	0.17	0.075	0.15
Density of communication network[1]	-0.085	0.15	-0.100	0.09	-0.116	0.05	-0.068	0.18	-0.071	0.17	-0.076	0.14
Higher density (>0.83) and lower size (1-2)[2]	Reference		Reference		Reference		Reference		Reference		Reference	
Middle density (0.71-0.83) and size (3)[2]	1.069	0.04	1.154	0.02	1.022	0.04	-0.108	0.79	-0.086	0.83	-0.055	0.89
Lower density (<0.71) and higher size (4-6)[2]	1.061	0.04	1.177	0.02	1.253	0.01	0.568	0.19	0.573	0.19	0.611	0.17
Social network activation												
Communication frequency[1]	-0.093	0.12	-0.088	0.13	-0.085	0.14	-0.124	0.01	-0.126	0.01	-0.136	0.007
Upper (365)	Reference		Reference		Reference		Reference		Reference		Reference	
Middle (208-364)	0.621	0.20	0.708	0.13	0.471	0.31	0.148	0.72	0.097	0.81	0.112	0.78
Lower (<208)	0.890	0.06	0.933	0.05	0.887	0.06	0.896	0.03	0.917	0.03	1.004	0.02
Meeting frequency[1]	-0.065	0.28	-0.062	0.29	-0.064	0.27	-0.118	0.02	-0.121	0.02	-0.134	0.009
Upper (365)	Reference		Reference		Reference		Reference		Reference		Reference	
Middle (186-364)	0.160	0.74	0.307	0.51	0.110	0.81	0.194	0.63	0.166	0.68	0.188	0.64
Lower (<186)	0.638	0.20	0.673	0.16	0.665	0.16	0.792	0.07	0.805	0.07	0.915	0.04

Model 1 adjusted for age and education; Model 2 added smoking, alcohol drinking, and depression score; and Model 3 added hypertension, diabetes, stroke, and arthritis.
[1]The rank transformation approach was used. β means the standardized β-coefficient.
[2]Before the analysis, unclassified individuals (3 men and 8 women) were removed.

was used. For the continuous variables, *p*-values were calculated by using a contrast to test for a linear trend. For the categorical variables, the Cochran-Armitage test was used. Multiple linear regression analyses were performed to assess the linear relationship between each of the social network measures and BMI. In the matter of network activation, communication frequency was more significant than meeting frequency from the aforementioned analyses. Lastly, both the group of social network structure (density and size) and communication frequency were included in the multiple regression model. All statistical tests were performed with SAS version 9.2 (SAS Inc., Cary, NC, USA). All analyses were two-sided and *p*-values <0.05 were regarded as statistically significant.

RESULTS

The characteristics of the study population are summarized in Table 1. We assessed the linear trends between the social network measures and BMI (Appendices 4-6). The group of social network structure and communication frequency were significantly associated with BMI in both the men and women. However, meeting frequency was only significant in the women.

Multiple linear regression analyses were performed to assess the relationship between each social network measure and BMI (Table 2). As regards network structure, rank-transformed network size and density were only associated with the men's BMI in model 3, while the group of network structure was significantly associated with BMI among all of the models in the men. The men with lower density and higher size had a higher BMI ($\beta=1.253$, $p=0.014$) than the men with higher density and lower size, while the men with middle density and size also had a higher BMI ($\beta=1.022$, $p=0.044$) compared with the reference group. We did not observe a significant association between network structure and BMI in the women. As regards network activation, communication frequency was significantly associated with the women's BMI among all of the models. The association between rank-transformed meeting frequency and the women's BMI was significant, but the tertile of meeting frequency was only associated in model 3. We did not observe such an association between network activation and BMI in the men.

The group of social network structure and the communica-

Table 3. Social network characteristics and body mass index: multiple linear regression

Variable	Men (n=270)		Women (n=376)	
	β	*p*-value	β	*p*-value
Age (y)	-0.054	0.08	-0.134	<0.001
Depression score (CES-D)	-0.015	0.60	-0.021	0.36
Education (y)				
≥10	Reference		Reference	
7-9	0.048	0.94	2.047	0.02
0-6	-0.855	0.10	2.265	0.002
Smoker vs. non-smoker	-1.690	<0.001	-0.380	0.75
Alcohol drinker vs. non-drinker	0.398	0.32	1.355	0.05
Comorbidity vs. non-comorbidity				
Hypertension	0.739	0.06	0.794	0.03
Diabetes	1.494	0.002	0.200	0.67
Stroke	0.776	0.37	0.658	0.45
Arthritis	-0.275	0.55	0.467	0.20
Social network structure				
Higher density (>0.83) and lower size (1-2)	Reference		Reference	
Middle density (0.71-0.83) and size (3)	0.936	0.07	-0.178	0.68
Lower density (<0.71) and higher size (4-6)	1.089	0.04	0.391	0.39
Communication frequency				
Upper (365)	Reference		Reference	
Middle (208-364)	0.405	0.39	0.091	0.83
Lower (<208)	0.702	0.14	0.885	0.05

Before the analysis, unclassified individuals (3 men and 8 women) were removed.
Adjusted for age, education, smoking, alcohol drinking, depression score, hypertension, diabetes, stroke, and arthritis.
CES-D, Center for Epidemiologic Studies-Depression Scale.

tion frequency as an index of network activation were further analyzed for the association with BMI in the men and women (Table 3). After adjusting for age, education, smoking, alcohol drinking, depression score, comorbidity (hypertension, diabetes, stroke, and arthritis), and communication frequency, the men with lower density (<0.71) and higher size (4-6) had a higher BMI (β=1.089, p=0.037) than the men with higher density (>0.83) and lower size (1-2), but this was not the case in the women (β=0.391, p=0.393). In contrast, after adjusting for potential confounders and social network structure, the lower tertile of communication frequency was associated with a higher BMI in the women (β=0.885, p=0.049), but not in the men (β=0.702, p=0.140). In the women, less education was prominently related with a higher BMI among potential confounders.

DISCUSSION

The present study examined the association between social network measures and BMI in an elderly Korean population. The men with a sparse and large communication network had a higher BMI compared with the men embedded in dense and small communication networks. The women in networks with a low frequency of communication had a higher BMI than the women in networks with a high frequency of communication.

Social contacts can promote, discourage, and sanction attitudes and behaviors [27,28]. Social contacts may influence participation in organized sports [29], dieting [30], and food choices [31]. A study has linked unhealthy weight-control behaviors among adolescent girls to the dieting behaviors of their peers [32]. We found that the men's BMI was more strongly associated with network structure, that is, network size and density, than communication frequency as an index of network activation. KSHAP data from a restricted rural area had a simpler network structure than the NSHAP data because the NSHAP study population was a nationally representative sample [24]. Almost the entire KSHAP study population existed in three of the nine possible density and size groups. Therefore, it was difficult to discriminate statistically the effect of density from the association between social network structure and BMI, because network size and density were strongly correlated. We postulate a possible explanation for the association between network structure and the men's BMI. Dense personal networks provide reinforcement for prevailing norms and practices and can provide protection from outside sources of influence or risk [25]. The greater the density, the more likely a network is to be considered a cohesive community, a source of social support, and an effective transmitter [33]. By contrast, the women's BMI was more strongly associated with network activation such as communication frequency than network structure. In the women, education was prominently related with BMI among potential confounders, such that more advanced education correlated with lower BMI. The well-educated have a healthier lifestyle [34]. They are more likely to exercise, less likely to smoke, and more likely to drink moderately rather than abstain or drink heavily. It could be inferred that individual attributes such as education level may be most important in determining women's BMI. A previous study explained possible reasons for gender differences in factors associated with BMI [35]. Social contact among friends may be qualitatively different for the men and women in relation to how they affect health behavior. Although not statistically significant in interaction terms (social network measures by gender), β-coefficient estimates that are markedly different from each other suggest the possibility of true interaction between gender and social network characteristics [36].

Previous studies have been mainly interested in the peer effect on obesity. There have been few reports about the association between other characteristics of social networks and obesity. Our findings were not definite, but might illuminate the novel association between social network structure or activation and BMI.

This study has several limitations. First, because of the cross-sectional design, this study could not establish a temporal relationship between BMI and social network characteristics. Second, the survey data were open to measurement error. In particular, the reported relationships among alters might differ from actual relationships. It is important to determine not only the association between an ego's health behavior and an actual social network, but the perceived social network as well. Third, we assumed an inverse linear relationship between BMI and health. However, an increased risk of death has been observed to be associated with a low BMI in other studies [37,38]. Inadequate or incomplete control for confounding or reverse-causation bias could in part explain the increased risk [39]. A low BMI can be an indicator of certain other chronic medical conditions [40]. We adjusted for comorbidities, such as hypertension, diabetes, stroke, and arthritis, in order to overcome this unintended effect. This study population was dwelling in the community, not institutions, and they completely responded to the long survey (mean response time: 70 minutes). It can thus be concluded that they were not unhealthy enough to induce a reverse-causation bias. Fourth, the questionnaires did not measure diet and physical activity. These factors are determinants for obesity, and taking them into account may be necessary to identify the behavioral process (indirect effect) of social networks on BMI [26]. We could not distinguish behavioral processes from psychological processes in this study. Fifth, external validity could be limited because all of the subjects in the study population resided in a single rural community. Accordingly, further longitudinal studies in urban and rural areas are needed.

Our study suggests that social network structure (network size and density) and activation (communication frequency and meeting frequency) are associated with obesity among the elderly. Lower density of communication network and higher network size may be associated with higher BMI in men, while lower frequency of communication may be associated with higher BMI in women.

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CONFLICT OF INTEREST

The authors have no conflicts of interest with the material presented in this paper.

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구분	연번	문7-1. 문7-2. 이름	문7-3. 관계	문8. 양사면 거주 여부	문8-1. 거주 "리"	문9. 연령	문10. 성별	문11. 학력	문12. 혹시 이분과 동거하고 계십니까?	문12-1. (비동거의 경우) 현재 거주지는 어디입니까?	문13. 알고 지낸 기간이 얼마나 되셨습니까?	문14. 이분과 얼마나 자주 이야기 하십니까?	문15. 이분과 직접 얼마나 자주 만나십니까?	문16. 이분과 얼마나 친하다고 생각하십니까?	문17. 건강에 문제가 있거나 건강과 관련한 중요한 결정을 할 때, 이분과 이야기하게 될 가능성이 얼마나 되는 것 같습니까?
구분	연번	전체성함기록 [불가피한경우에만 애칭기록]	관계보기 참조	①예 ②아니오	①철산리 ②덕하1리 ③덕하2리 ④덕하3리 ⑤북성1리 ⑥북성2리 ⑦교산1리 ⑧교산2리 ⑨인하1리 ⑩인하2리	(____)세	①남 ②여	①무학 ②초등학교 ③중학교 ④고등학교 ⑤전문대 ⑥4년제대학 ⑦대학원 ⑨모름	①동거 ②비동거	①서울 ②부산 ③대구 ④인천 ⑤광주 ⑥대전 ⑦울산 ⑧경기 ⑨강원 ⑩충북 ⑪충남 ⑫전북 ⑬전남 ⑭경북 ⑮경남 ⑯제주	( )년	①매일 ②일주일에 여러번 ③일주일에 한번 ④2주일에 한번 ⑤한달에 한번 ⑥일년에 여러번 ⑦일년에 1번 ⑧일년에 1번 미만	①매일 ②일주일에 여러번 ③일주일에 한번 ④2주일에 한번 ⑤한달에 한번 ⑥일년에 여러번 ⑦일년에 1번 ⑧일년에 1번 미만 ⑨한번도 없다	①그리 친하지 않다 ②어느정도 친하다 ③많이 친하다 ④아주 많이 친하다	①매우 가능성이 높다 ②어느 정도 가능성이 있다 ③거의 가능성이 없다
배우자	1		1												
가장 자주 이야기하는 분들부터 순서대로 5명	1														
	2														
	3														
	4														
	5														
가장 가깝고 중요한 1명	6														

관 계 보 기			
1) 배우자	2) 남자친구 또는 여자친구 (애인)	3) 친부모님	4) 시부모님 또는 장인/장모
5) 자녀	6) 자녀의 배우자 (사위 또는 며느리)	7) 손자녀	8) 형제자매
9) 다른 친인척	10) 동네이웃	11) 동네이웃이 아닌 친구	12) 성직자 (집사, 전도사, 목사, 신부, 스님 등)
13) 의료기관 종사자(의사, 간호사, 상담사, 침쟁이 등)		14) 사회복지사	15) 기타 (누구인지 관계를 반드시 적을 것)

Appendix 1. Social network card I.

문18. 이름1과 이름2는 서로 얼마나 친하게 지냅니까?

구분	배우자	이름1	이름2	이름3	이름4	이름5	이름6
배우자:							
이름1:							
이름2:							
이름3:							
이름4:							
이름5:							
이름6:							

① 전혀 모른다 ② 그리 친하지 않다
③ 어느정도 친하다 ④ 많이 친하다
⑤ 아주 많이 친하다

문19. 이름1과 이름2는 얼마나 서로 자주 이야기를 합니까?

구분	배우자	이름1	이름2	이름3	이름4	이름5	이름6
배우자:							
이름1:							
이름2:							
이름3:							
이름4:							
이름5:							
이름6:							

① 매일 ② 일주일에 여러번 ③ 일주일에 한번
④ 2주일에 한번 ⑤ 한 달에 한번 ⑥ 일 년에 여러번
⑦ 일년에 1번 ⑧ 일 년에 1번미만 ⑨ 한번도 서로 이야기해본 적 없다

Appendix 2. Social network card II.

Appendix 3. Network size and density of communication network

Density of communication network	Men (n=273)			Women (n=384)		
	Lower (1-2)	Middle (3)	Higher (4-6)	Lower (1-2)	Middle (3)	Higher (4-6)
Higher (>0.83)	62 (23)	0 (0)	0 (0)	139 (36)	0 (0)	0 (0)
Middle (0.71-0.83)	0 (0)	104 (38)	0 (0)	0 (0)	127 (33)	0 (0)
Lower (<0.71)	0 (0)	3 (1)	104 (38)	2 (1)	6 (2)	110 (29)

Values are presented as number (%).

Appendix 4. Participant characteristics according to social network structure

Variable	Men (n=273)					Women (n=384)				
	Higher density and lower size (n=62)	Middle density and size (n=104)	Lower density and higher size (n=104)	Unclassified (n=3)	*p* for trend[1]	Higher density and lower size (n=139)	Middle density and size (n=127)	Lower density and higher size (n=110)	Unclassified (n=8)	*p* for trend[1]
Age (y)	73.8±8.6	72.7±7.0	72.3±6.1	71.3±7.5	0.21	74.5±8.4	70.7±8.1	69.6±6.9	69.6±9.3	<0.001
BMI (kg/m^2)	22.6±3.4	23.8±3.5	23.9±2.9	24.1±2.1	0.01	23.9±3.4	24.1±3.5	24.9±3.4	24.5±2.3	0.03
Depression score (CES-D)	13.9±8.9	9.7±7.0	8.8±7.0	6.0±2.6	<0.001	13.7±8.8	11.1±7.3	10.6±7.2	7.5±5.5	0.002
Communication frequency	278.4±91.4	256.1±95.5	219.8±104.4	169.2±22.3	<0.001	284.1±102.4	250.9±103.3	214.4±98.7	190.6±52.7	<0.001
Meeting frequency	275.2±92.1	250.8±101.2	204.1±108.3	157.9±32.7	<0.001	276.0±112.5	240.2±110.2	191.4±108.0	185.0±54.3	<0.001
Education (y)					0.07					0.004
≥7	19 (31)	42 (40)	47 (14)	3 (100)		13 (9)	20 (16)	25 (23)	4 (50)	
0-6	43 (69)	62 (60)	57 (55)	0 (0)		126 (91)	107 (84)	85 (77)	4 (50)	
Smoker	42 (68)	70 (67)	76 (73)	2 (67)	0.41	3 (2)	4 (3)	1 (1)	0 (0)	0.54
Alcohol drinker	25 (40)	40 (38)	52 (50)	1 (33)	0.16	12 (9)	7 (6)	6 (5)	0 (0)	0.30
Comorbidity										
Hypertension	28 (45)	52 (50)	41 (39)	2 (67)	0.35	86 (62)	68 (54)	55 (50)	4 (50)	0.06
Diabetes	14 (23)	25 (24)	18 (17)	0 (0)	0.35	21 (15)	19 (15)	22 (20)	1 (13)	0.32
Stroke	5 (8)	6 (6)	3 (3)	0 (0)	0.14	11 (8)	3 (2)	2 (2)	0 (0)	0.01
Arthritis	12 (19)	28 (27)	26 (25)	0 (0)	0.49	70 (50)	67 (53)	54 (49)	4 (50)	0.87

Values are presented as mean±standard deviation or number (%).
The significance of differences across groups was assessed using trend tests.
BMI, body mass index; CES-D, Center for Epidemiologic Studies-Depression Scale.
[1]Before the analysis, unclassified individuals (3 men, 8 women) were removed.

Appendix 5. Participant characteristics according to average frequency of communication

Variable	Men (n=273)				Women (n=384)			
	Upper (365) (n=85)	Middle (208-364) (n=92)	Lower (<208) (n=96)	*p* for trend	Upper (365) (n=135)	Middle (208-364) (n=130)	Lower (<208) (n=119)	*p* for trend
Age (y)	72.7±6.3	73.8±7.2	72.0±7.5	0.51	73.6±7.8	71.0±8.3	70.4±8.0	0.002
BMI (kg/m²)	23.0±3.3	23.5±3.4	24.1±3.0	0.03	23.9±3.1	24.2±3.5	24.8±3.7	0.03
Depression score (CES-D)	10.4±6.7	10.4±7.9	10.1±8.3	0.75	12.1±7.9	11.0±7.6	12.5±8.3	0.64
Network size	3.0±1.3	3.3±1.1	3.7±1.2	<0.001	2.5±1.0	3.1±1.2	3.4±1.2	<0.001
Density of communication network	0.78±0.11	0.75±0.07	0.72±0.07	<0.001	0.81±0.09	0.76±0.08	0.74±0.09	<0.001
Education (y)				0.01				0.005
≥7	28 (33)	45 (37)	49 (51)		13 (10)	22 (17)	27 (23)	
0-6	57 (67)	23 (63)	47 (49)		122 (90)	108 (83)	92 (77)	
Smoker	58 (68)	64 (70)	68 (71)	0.71	4 (3)	2 (2)	2 (2)	0.46
Alcohol drinker	41 (48)	32 (35)	45 (47)	0.91	8 (6)	11 (8)	6 (5)	0.81
Comorbidity								
Hypertension	31 (36)	45 (49)	47 (49)	0.10	84 (62)	68 (52)	61 (51)	0.07
Diabetes	17 (20)	23 (25)	17 (18)	0.67	19 (14)	21 (16)	23 (19)	0.26
Stroke	4 (5)	8 (9)	2 (2)	0.39	6 (4)	7 (5)	3 (3)	0.46
Arthritis	19 (22)	26 (28)	21 (22)	0.91	73 (54)	71 (55)	51 (43)	0.08

Values are presented as mean±standard deviation or number (%).
The significance of differences across groups was assessed using trend tests.
BMI, body mass index; CES-D, Center for Epidemiologic Studies-Depression Scale.

Appendix 6. Participant characteristics according to average frequency of meeting

Variable	Men (n=273)				Women (n=384)			
	Upper (365) (n=83)	Middle (186-364) (n=103)	Lower (<186) (n=87)	*p* for trend	Upper (365) (n=131)	Middle (186-364) (n=134)	Lower (<186) (n=119)	*p* for trend
Age (y)	72.7±6.4	74.1±7.1	71.3±7.4	0.23	73.9±7.6	71.4±8.0	69.7±8.3	<0.001
BMI (kg/m²)	23.2±3.4	23.4±3.3	24.1±3.2	0.08	23.9±3.1	24.3±3.3	24.7±3.8	0.04
Depression score (CES-D)	10.4±6.5	10.5±7.9	10.0±8.5	0.74	12.2±7.8	11.7±7.9	11.6±8.2	0.60
Network size	3.0±1.3	3.2±1.2	3.9±1.1	<0.001	2.5±1.0	2.9±1.2	3.5±1.2	<0.001
Density of communication network	0.79±0.11	0.76±0.07	0.71±0.06	<0.001	0.81±0.09	0.77±0.09	0.73±0.09	<0.001
Education (y)				0.04				<0.001
≥7	26 (31.3)	44 (42.7)	41 (47.1)		11 (8.4)	19 (14.2)	32 (26.9)	
0-6	57 (68.7)	59 (57.3)	46 (52.9)		120 (91.6)	115 (85.8)	87 (73.1)	
Smoker	55 (66.3)	76 (73.8)	59 (67.8)	0.84	3 (2.3)	3 (2.2)	2 (1.7)	0.74
Alcohol drinker	39 (47.0)	39 (37.9)	40 (46.0)	0.91	8 (6.1)	11 (8.2)	6 (5.0)	0.76
Comorbidity								
Hypertension	32 (38.6)	50 (48.5)	41 (47.1)	0.27	84 (64.1)	72 (53.7)	57 (47.9)	0.01
Diabetes	17 (20.5)	25 (24.3)	15 (17.2)	0.59	19 (14.5)	23 (17.2)	21 (17.7)	0.50
Stroke	4 (4.8)	8 (7.8)	2 (2.3)	0.44	5 (3.8)	9 (6.7)	2 (1.7)	0.43
Arthritis	21 (25.3)	28 (27.2)	17 (19.5)	0.37	72 (55.0)	71 (53.0)	52 (43.7)	0.08

Values are presented as mean±standard deviation or number (%).
The significance of differences across groups was assessed using trend tests.
BMI, body mass index; CES-D, Center for Epidemiologic Studies-Depression Scale.