6

7   **Social Relationships and Onset of Functional Limitation Among Older**

8   **Adults with Chronic Conditions**

9   *Does Gender Matter?*

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22

23   **Abstract**

24   *Objective:* This study aimed to examine the longitudinal association between social

25   relationships and physical functioning among community-dwelling older adults with chronic

26   conditions. *Methods:* Self-reported questionnaires were distributed and collected between

27   2014 and 2017 from participants aged 65 years and older. The Index of Social Interaction was

28   used to evaluate social relationships, and the instrumental activities of daily living (IADL)

29 subscale of the Tokyo Metropolitan Institute of Gerontology Index of Competence was used

30 to examine functional status. Data from 422 participants (190 men and 232 women) were

31 included in the final analysis. ***Results:*** High social relationships demonstrated significant

32 adverse effects (OR = 0.77, 95% CI = 0.64 – 0.93) on the decline of IADL in the overall

33 sample, particularly for women (OR = 0.71, 95% CI = 0.55 – 0.93) but not for men (p =

34 0.131). ***Conclusion:*** The finding suggests that functional limitation was influenced by social

35 relationships among the disabled older adults, and the influence of social relationships on

36 functional limitation differed based on gender.

37 ***Keywords:*** Interpersonal Relations; Functional Status; Gender; Aged; Chronic Disease;

38 Longitudinal Studies; Health Behaviour.

39

40 **Advances in Knowledge**

41 1. This study found that social relationships may prevent physical deterioration among

42   people with chronic conditions.

43 2. This positive association was observed among a female group, whereas no effect was

44   found among a male group.

45 3. Taking measures to promote social relationships and being aware of gender differences

46   may improve the physical function of older adults with chronic conditions.

47

48 **Application to Patient Care**

49 1. Physicians, nurses, and other health professionals should encourage older people to

50   engage in social relations that will benefit disabled older people's health outcomes.

51 2. Social relationships should be a focus of chronic disease management.

52

53 **Introduction**

54 Aging is a global public issue, with at least one person out of eleven people being above 65

55 years of age in 2019. This number is expected to rise, with the older person being out of only

56 six people, by 2050.[1] In Japan, the aging rate is 28.8% (about one out of four people) of the

57 total population as of 2020.[2] Most countries are experiencing not only a rapidly ageing

58 population but also the impact of related functional limitations. The latter refers to physical

89 support impacts functional impairment in both genders. Hence, consistent results regarding

90 the influence of gender on social relationships and health have not been established. Further,

91 gender differences have not been thoroughly investigated in studies on individuals with

92 chronic diseases.

93

94 To address these gaps in the research, the current study examined the association between

95 social relationships and functional status among older adults with chronic diseases and

96 assessed the effects of gender on these associations. The results can be used to further the

97 understanding of social relationships and provide evidence for disease management to delay

98 deterioration and improve health-related quality of life for older adults with chronic diseases.

99

100 **Methods**

101 *Design and participants*

102 Data for this three-year longitudinal study were extracted from a single-centre cohort project,

103 the Community Empowerment and Care for well-being and Health Longevity (CEC), which

104 was established in Japan in 1991. The CEC aims to explore the factors related to the well-

105 being of residents in the context of the low birth rate, ageing population, and high medical

106 expenditure. This project was conducted in Tobishima in Aichi Ken, central Japan; the entire

107 population of around 4,800 participated in the survey. In 2020, the ageing rate was

108 approximately 28.0%. Our research project was conducted in collaboration with the local

109 government municipality's health policy evaluation, and our survey period was consistent

110 with that of the municipal survey. Before 2011, the survey was conducted every one or two

111 years. Since 2011, the survey has been conducted every three years. In each wave, the survey

112 is performed from April to May. To avoid selection bias, all the residents were invited to and

113 agreed to participate in the survey. Questionnaires were mailed to all residents. The

114 questionnaire encompassed demographic characteristics, nutrition, lifestyle habits, long-term

115 care needs evaluation, evaluation of local services, social relationships, and medical

116 conditions.

117

118 Unlike previous research related to this project, in the present study, we focused on older

119 adults living with chronic disease. We used data collected from individuals aged 65 years and

120 older with at least one chronic medical condition in 2014. The inclusion criteria were: (1)

121 people with at least one chronic disease (hypertension, stroke, heart disease, diabetes,

122 hyperlipidaemia, lung disease, arthritis, cancer, immune disease, depression, eye disease, and

123 ear disease), (2) physically independent at baseline, and (3) no missing information on IADL.

124 In 2014, 523 individuals who fit the inclusion criteria were enrolled. The chronic conditions

125 were determined using the question, 'Do you have an illness that is being treated, or do you

126 suffer from an illness sequela?' In 2017, a follow-up study was conducted to assess the

127 participants for symptoms of physical functional decline. The data were collected from 1

128 April to 15 May in 2014 and 2017. Between 2014 and 2017, 55 participants could not be

129 reached for the follow-up, and 46 participants were excluded owing to missing IADL

130 information (Figure 1). We calculated the required sample size using the G*power. A

131 minimal sample size of 191 was required based on the expected 0.8 power and a 0.05 level of

132 significance.

133

134 *Measurements*

135 Functional competence was assessed by the IADL subscale of the Tokyo Metropolitan

136 Institute of Gerontology Index of Competence. The IADL subscale comprises five items:

137 using public transportation, shopping, preparing meals, paying bills, and individual banking

138 management. For each item, a positive response was coded as 1, and a negative response was

139 coded as 0. For example, regarding the use of public transportation, the response options to

140 the question 'Do you use public transportation (bus or train) to go out on your own?' were 'I

141 can and do', 'I can but do not', and 'I cannot'. A response of 'I cannot' received 0 point,

142 whereas the other two responses received 1 point. The total score ranged from 0 to 5, and a

143 score of 5 was considered a normal IADL, while a score of 0–4 indicated a low IADL.[18]

144

145 The Index of Social Interaction (ISI) was used to evaluate social relationships.[19] The ISI

146 includes five subscales and 18 items. The Independence subscale has four items to assess

147 motivation to live, motivation to maintain a healthy life, taking an active approach towards

148 life, and having a regular lifestyle. The Social Curiosity subscale measures habits of reading

149 newspapers and books, using new equipment (e.g., a video system), hobbies, and a feeling of

150 importance in society. The Interaction subscale measures communication with family

151 members and non-family members and interacting with non-family members. The

152 Participation subscale measures participation in social groups, in neighbourhood groups,

153 watching television, and taking an active social role. The Feelings of Safety subscale tests if

154 participants have someone who can offer counselling and provide support during

155 emergencies. For all items, a positive response was coded as 1, and a negative response was

156 coded as 0. Taking 'Do you have someone to counsel in a difficult situation?' as an example,

157 the response options were 'always', 'frequently', 'sometimes', and 'never'. A response of

158 'never' received 0 point, while the other three received 1 point. The total score was 18, with a

159 higher score indicating good social interaction. The ISI was taken as a continuous variable in

160 the analysis.

161

162 In accordance with previous studies,[12,20] we considered age, sex, living status, exercise,

163 smoking, and drinking as covariates. Age was measured as a continuous variable. Exercise

164 was evaluated by the question 'Do you usually exercise?' and was categorised as 'yes' if their

165 response were 'always' or 'sometimes' and 'no' if otherwise. Living status was evaluated by

166 asking if the participants lived alone or with others. Living with others included spouses,

167 sons, daughters, daughters-in-law, grandsons, brothers/sisters, and others. Smoking was

168 evaluated by the question 'Do you smoke?'; those who responded 'every day' or 'sometimes'

169 were regarded as current smokers, 'previously did but have stopped now' as ex-smokers, and

170 'do not smoke' as non-smokers. Drinking was assessed by an item 'Do you drink?' and was

171 dichotomised as yes if participants answered 'every day' or 'sometimes' and no if they

172 answered 'do not drink'.

173

174 ***Statistical analysis***

175 Baseline demographic information between gender groups was compared by chi-square ($\chi 2$)

176 tests or non-parametric tests. These tests were also implemented to examine demographic

177 information and the IADL for categorical and continuous variables, respectively. A multiple

178 logistic regression analysis was performed to examine the association between social

179 relationships and declining IADL after controlling for covariates that were statistically

180 significantly associated with IADL in the chi-square or non-parametric tests. We then fitted

181 additional models to examine gender differences in the association between the ISI and IADL

182 using a gender stratified analysis. A sensitive analysis was also completed to compare the

183 demographic differences between included and excluded cases. All the analyses were

184 performed using IBM SPSS 26.0.

185

186 *Ethical consideration*

187 This study was approved by the University of Tsukuba Ethics Committee (No. 1331-1). The

188 survey data were anonymously provided by the local government.

189

190 **Results**

191 Data from 422 individuals were included in the analysis. Of the 422 participants, most were

192 women, not living alone, doing exercise, non-drinkers, non-smokers, and diagnosed with one

193 chronic disease. While social relationships, age, living status, exercise, and disease status did

194 not differ between women and men, drinking and smoking differed significantly. Specifically,

195 men reported higher percentages of smoking and drinking [Table 1].

196

197 The bivariate analysis demonstrated that age, exercise, and social relationships were

198 associated with the IADL after three years [Tables 2 and 3]. After controlling for age and

199 exercise in the logistic regression models, the results demonstrated that higher social

200 relationship index was (OR = 0.77, 95% CI =0.64–0.93) inversely associated with a low

201 IADL [Table 4].

202

203 The sex-stratified data revealed different results. In Model 1, higher social relationship index

204 demonstrated a significant inverse association with a low IADL in men (OR= 0.77, 95% CI =

205 0.61–0.98) and women (OR= 0.69, 95% CI = 0.56–0.85). After adjusting for age (Model 2)

206 and exercise (Model 3), higher social relationship index was inversely related to low IADL in

207 women (OR = 0.66, 95% CI = 0.51–0.86 and OR = 0.71, 95% CI = 0.55–0.93, respectively).

208 However, social relationships index adjusted for age and exercise demonstrated no statistical

209 association with a low IADL in men, with $p = 0.070$ and $p = 0.131$ (Table 4).

210

211 The sensitive analysis demonstrated the difference in age between the excluded case (72.9 $\pm$

212 6.0) and included case (75.9 $\pm$ 6.6). The excluded group is older than the included cases ($p <$

213 0.05), and a gender difference was not observed.

214

215 **Discussion**

216 This study examined the effects of social relationships on the functional status of older adults

217 with chronic conditions. The results demonstrated that higher social relationship index could

218 reduce older adults' functional decline. However, the beneficial effects of social relationship

219 index are significantly evident only among women.

220

221 The stress-buffering model and main effect model are the two main theoretical models linking

222 social relationships to health outcomes.[21] The stress-buffering model posits that social

223 resources, such as social companionship, may reduce stress by increasing positive moods. The

224 main effect model proposes that social support can reduce problematic behaviours (e.g.,

225 smoking, drinking, and not seeking medical help) associated with poor health outcomes.

226 Based on these theoretical models, chronic diseases and their consequences are stressors,

227 which may be reduced by their social resources. Meanwhile, social relationships can directly

228 benefit functional status.

229

230 Social relationships seem to have adverse effects on the functional decline among older adults

231 with chronic diseases. This result aligns with previous research[22] conducted in six countries,

232 which demonstrated that social capital and well-being were positively associated, regardless

233 of chronic diseases. A systematic review indicated that social relationships play an important

234 role in improving well-being and mental health among people with disabilities.[23] Moreover,

235 another previous study also demonstrated that strong social relationships could decrease

236 functional decline even among individuals with multiple chronic diseases.[20] Social relations

237 affect health outcomes through a reciprocity exchange[24]— social relations might enhance

238 resources, including transportation support and caring, which can affect health-related

239 behaviours. For instance, social contacts may allow individuals with chronic diseases to

240 undergo medical check-ups, access important health-related information, and gain confidence

241 in health-promoting behaviours, which can delay the onset of physical decline.

242

243 Chronic diseases are usually lifelong and cause earlier functional limitations; subsequently,

244 measures should be taken to prevent the deterioration of these conditions. This study

245 contributes to the existing literature through the identification of a cost-effective method to

246 gather evidence for chronic disease management. Being aware of the benefits of social

247 relationships for health outcomes may provide evidence and directions for chronic disease

248 management and suggests that health promotion programmes should be expanded to include

249 social relationships and traditionally modified factors (e.g., physical activity and healthy

250 eating behaviour).

251

252 Our findings further indicated that higher social relationship index could reduce the

253 probability of functional decline among women but not men. This finding aligns with a

254 previous 10-year longitudinal study[25] that found that women with positive social support had

255 lower mortality risks than those with poor social support; however, this association was not

256 observed among men. Additionally, another longitudinal study examining the effects of

257 participation in social activities and cognitive decline among older adults found that social

258 activities impacted cognitive decline only among women.[26] The benefits women experience

259 due to strong social relationships are particularly relevant in potentially improving their

260 conditions as women with chronic diseases are more likely to experience functional

261 disabilities.[27] One plausible reason is that women generally maintained stability in their social

262 activities, whereas men's social activities declined over time.[28] Moreover, older women tend

263 to have larger social networks than older men.[29] These findings support our results on the

264 gender-moderated effects of social relationships on functional status.

265

266 It is already known that behaviour change and improvements in the treatment of chronic

267 diseases may improve quality of life.[30] Our study demonstrated that social relationship index,

268 which encompass independence, social curiosity, interaction with others, participating in

269 social activities, and feeling safe in daily life, are effective in maintaining physical function.

270 Regarding the practical implications of these findings, physicians, nurses, and social workers

271 need to consider the impact of social relationships on health and develop chronic disease

272 management interventions such as promoting interactions with family and non-family

273 members, using new equipment (e.g., video camera, internet), and reading newspapers.

274 Moreover, team-based strategies should be developed; these must include various parties such

275 as medical staff, social workers, health policymakers, and other health stakeholders. Further,

276 considering the gender differences in the effects of social relationships on health, more

277 integration measures should be included for men. Additionally, longitudinal research could

278 facilitate the identification of other relevant aspects of men's social relations.

279

280 This study has several limitations. First, disease severity and duration were not examined,

281 which may have affected the results. Individuals with more severe and longer-lasting chronic

282 diseases may experience worse functional deterioration. Subsequently, it is unclear if the

283 effects of social relationships differ among people with chronic diseases of different severity

284 and duration. Further studies taking disease severity and duration into consideration are

285 therefore necessary. Second, although some diseases can affect individuals' social

286 interactions, we did not explore the effect of social relationships on functional limitation by

287 individual diseases. Identifying the effects of specific diseases may facilitate the development

288 of targeted measures. Third, the specific types and frequency of social relationships index

289 were not examined. Knowing the specific source of social relationships would yield more

290 specific evidence for intervening to promote social engagement. Fourth, only one indicator

291 was used to examine functional status; combining subjective and objective measurements for

292 functional indicators might strengthen the reliability of the results. Fifth, even though we

293 highlighted the importance of social relationship index with regards to decreasing the odds of

294 functional decline, we did not examine interaction effects. Thus, studies examining the

295 interaction effects (multiplicative or additive) of social relationship index and chronic

296 conditions, which might offer deeper insight into the target population, will be significant for

297 public health and psychosocial research. Finally, this study was conducted in one area, which

298 may limit the generalisability of the results. Considering that culture is crucial to social

299 relationships, studies using data from various countries to provide insight into the

300 comparative impacts of social relationships on health outcomes across cultures are necessary.

301

302 Despite these gaps, this study addresses the association between social relationships and

303 functional status among community-dwelling older adults with chronic conditions and gender

304 differences. Our results further imply that it may be beneficial to consider gender differences

305 when encouraging social relationships for disease management. A better understanding of

306 gender-based differences can help develop further interventional programmes and studies to

307 promote health outcomes linked to gender differences.

308

309 **Conclusion**

310 Social relationships influence physical functioning among older adults with chronic diseases.

311 Based on the results of this study, among people with chronic disease, social relationships

312 were related to functional decline after three years; further, this association differed by

313 gender. Professionals should assist older adults with developing, maintaining, and

314 strengthening their social relations in daily life through interventions such as using new

315 equipment, interacting with family and non-family members, participating in various

316 activities, receiving support from others, and taking an active approach to life, to increase the

317 sustainability of their functional independence. Given their significance, social relationships

318 should form an important part of health policy decisions. Further, being aware of the

319 moderating effects of gender differences may facilitate the development of more appropriate

320 measures to reduce functional decline among older adults, and encouraging older women to

321 maintain social relationships may be effective in reducing their vulnerability to functional

322 limitations.

323

324 **Conflict of Interest**

325 The authors declare no conflicts of interest.

326

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331   **Authors' Contribution**

332   DJ and TA conceptualised and designed the study. ET, TW and YS collected the data. DJ and

333   KW analysed and interpreted the data. All authors were involved in the study investigation.

334   SI, RO, YK and TA handled the project administration. DJ drafted the manuscript. YS, MM

335   and AA reviewed and edited the manuscript. TA supervised the study and acquired the

336   funding. All authors approved the final version of the manuscript.

337

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342

343   **References**

344   1. World population ageing 2019: highlights New York City United Nations, department of

345   economic and social affairs, population division; 2019. From:

346   https://www.un.org/en/development/desa/population/publications/pdf/ageing/WorldPopul

347   ationAgeing2019-Highlights.pdf   Accessed: Jul 2020.

348   2. Statistic Bureau of Japan. Statistic handbook of Japan 2021. From:

349   https://www.stat.go.jp/english/data/handbook/c0117.html   Accessed: Dec 2021.

350   3. Verbrugge LM, Jette AM. The disablement process. Soc Sci Med 1994; 38(1):1–14.

351   https://doi.org/10.1016/0277-9536(94)90294-1.

352   4. Fong JH. Disability incidence and functional decline among older adults with major

353   chronic diseases. BMC Geriatr 2019; 19(1):323. https://doi.org/10.1186/s12877-019-

354   1348-z.

355   5. Deandrea S, Bravi F, Turati F, Lucenteforte E, La Vecchia C, Negri E. Risk factors for

356   falls in older people in nursing homes and hospitals. A systematic review and meta-

357   analysis. Arch Gerontol Geriatr 2013; 56(3):407–415.

358   https://doi.org/10.1016/j.archger.2012.12.006.

359   6.   Mutikainen S, Rantanen T, Alén M, Kauppinen M, Karjalainen J, Kaprio J, et al. Walking

360   ability and all-cause mortality in older women. Int J Sports Med 2011; 32(3):216–222.

361   https://doi.org/10.1055/s-0030-1268506.

362   7.   McGilton KS, Vellani S, Yeung L, Chishtie J, Commisso E, Ploeg J, et al. Identifying

363   and understanding the health and social care needs of older adults with multiple chronic

364   conditions and their caregivers: a scoping review. BMC Geriatr 2018; 18(1):231.

365   https://doi.org/10.1186/s12877-018-0925-x.

366   8.   Conde-Sala JL, Garre-Olmo J, Calvó-Perxas L, Turró-Garriga O, Vilalta-Franch J.

367   Course of depressive symptoms and associated factors in people aged 65+ in Europe: A

368   two-year follow-up. J Affect Disord 2019; 245:440–450.

369   https://doi.org/10.1016/j.jad.2018.10.358.

370   9.   Takahashi S, Ojima T, Kondo K, Shimizu S, Fukuhara S, Yamamoto Y. Social

371   participation and the combination of future needs for long-term care and mortality among

372   older Japanese people: A prospective cohort study from the Aichi Gerontological

373   Evaluation Study (AGES). BMJ Open 2019; 9:e030500.

374   https://doi.org/10.1136/bmjopen-2019-030500.

375   10. Yu B, Steptoe A, Niu K, Jia X. Social Isolation and Loneliness as Risk Factors for Grip

376   Strength Decline Among Older Women and Men in China. J Am Med Dir Assoc 2020;

377   21(12):1926-1930. https://doi.org/10.1016/j.jamda.2020.06.029.

378   11. Cwirlej-Sozanska A, Wisniowska-Szurlej A, Wilmowska-Pietruszynska A, Sozanski B.

379   Determinants of ADL and IADL disability in older adults in southeastern Poland. BMC

380   Geriatr 2019; 19(1):297. https://doi.org/10.1186/s12877-019-1319-4.

381   12. Griffith LE, Raina P, Levasseur M, Sohel N, Payette H, Tuokko H, et al. Functional

382   disability and social participation restriction associated with chronic conditions in

383   middle-aged and older adults. J Epidemiol Community Health 2017; 71(4):381–389.

384   https://doi.org/10.1136/jech-2016-207982.

385   13. Guida JL, Holt CL, Dallal CM, He X, Gold R, Liu H. Social relationships and functional

386   impairment in aging cancer survivors: A longitudinal social network study. Gerontologist

387   2020; 60(4):607–616. https://doi.org/10.1093/geront/gnz051.

388   14. Levy AM, Deschênes SS, Burns RJ, Elgendy R, Schmitz N. Trajectories of social support

389   in adults with type 2 diabetes: Associations with depressive symptoms and functional

390   disability. Int J Geriatr Psychiatry 2019; 34(3):480–487.

391   https://doi.org/10.1002/gps.5042.

392   15. Chemaitelly H, Kanaan C, Beydoun H, Chaaya M, Kanaan M, Sibai AM, et al. The role

393   of gender in the association of social capital, social support, and economic security with

394   self-rated health among older adults in deprived communities in Beirut. Qual Life Res

395   2013; 1371–1379. https://doi.org/10.1007/s11136-012-0273-9.

396   16. Lee S, Lee S, Lee E, Youm Y, Cho HS, Kim WJ. Gender differences in social network of

397   cognitive function among community-dwelling older adults. Geriatr Gerontol Intl 2020;

398   20(5):467–473. https://doi.org/10.1111/ggi.13906.

399   17. Hajek A, Brettschneider C, Mallon T, van der Leeden C, Mamone S, Wiese B, et al. How

400   does social support affect functional impairment in late life? Findings of a multicenter

401   prospective cohort study in Germany. Age Ageing 2017; 46(5):813–820.

402   https://doi.org/10.1093/ageing/afx012.

403   18. Ishizaki T, Kai I, Kobayashi Y, Imanaka Y. Functional transitions and active life

404   expectancy for older Japanese living in a community. Arch Gerontol Geriatr 2002;

405   35(2):107–120. https://doi.org/10.1016/s0167-4943(02)00002-x.

406   19. Anme T, Shimada C. Social interaction and mortality in a five-year longitudinal study of

407   the elderly. Jpn J Public Health 2000; 47:127–133. [In Japanese]

408   20. Jiao D, Watanabe K, Sawada Y, Tanaka E, Watanabe T, Tomisaki E, et al.

409   Multimorbidity and functional limitation: The role of social relationships. Arch Gerontol

410   Geriatr 2020; 92:104249. https://doi.org/10.1016/j.archger.2020.104249. Epub ahead of

411   print.

412   21. Cohen S, Wills TA. Stress, social support, and the buffering hypothesis. Psychol Bull

413   1985; 98(2):310–357.

414   22. Christian AK, Sanuade OA, Okyere MA, Adjaye-Gbewonyo K. Social capital is

415   associated with improved subjective well-being of older adults with chronic non-

416   communicable disease in six low- and middle-income countries. Global Health 2020;

417   16(1):2. https://doi.org/10.1186/s12992-019-0538-y.

418   23. Tough H, Siegrist J, Fekete C. Social relationships, mental health and well-being in

419   physical disability: A systematic review. BMC Pub Health 2017; 17(1): 414.

420   https://doi.org/10.1186/s12889-017-4308-6.

421   24. Cockerham WC, Hamby BW, Oates GR. The social determinants of chronic disease. Am

422   J Prev Med 2017; 52(1s1):S5–S12. https://doi.org/10.1016/j.amepre.2016.09.010.

423   25. Lyyra TM, Heikkinen RL. Perceived social support and mortality in older people. J

424   Gerontol B Psychol Sci Soc Sci 2006; 61(3):S147–152.

425   https://doi.org/10.1093/geronb/61.3.s147.

426   26. Hwang J, Park S, Kim S. Effects of participation in social activities on cognitive function

427   among middle-aged and older adults in Korea. Int J Environ Res Public Health 2018;

428   15(10):2315. https://doi.org/10.3390/ijerph15102315.

429   27. Calderón-Larrañaga A, Santoni G, Wang HX, Welmer AK, Rizzuto D, Vetrano DL, et al.

430   Rapidly developing multimorbidity and disability in older adults: Does social background

431   matter?. J Intern Med 2018; 283(5):489–499. https://doi.org/10.1111/joim.12739.

432   28. Finkel D, Andel R, Pedersen NL. Gender differences in longitudinal trajectories of

433   change in physical, social, and cognitive/sedentary leisure activities. J Gerontol B

434   Psychol Sci Soc Sci 2018; 73(8):1491–1500. https://doi.org/10.1093/geronb/gbw116.

435   29. Pillemer S, Ayers E, Holtzer R. Gender-stratified analyses reveal longitudinal

436   associations between social support and cognitive decline in older men. Aging Ment

437   Health. 2019;23(10):1326-1332. https://doi: 10.1080/13607863.2018.1495178.

438   30. Preventing non-communicable diseases. [Internet]. Geneva: World Health Organization.

439   Available from: https://www.who.int/activities/preventing-noncommunicable-diseases

440   Accessed: Jan 2020.
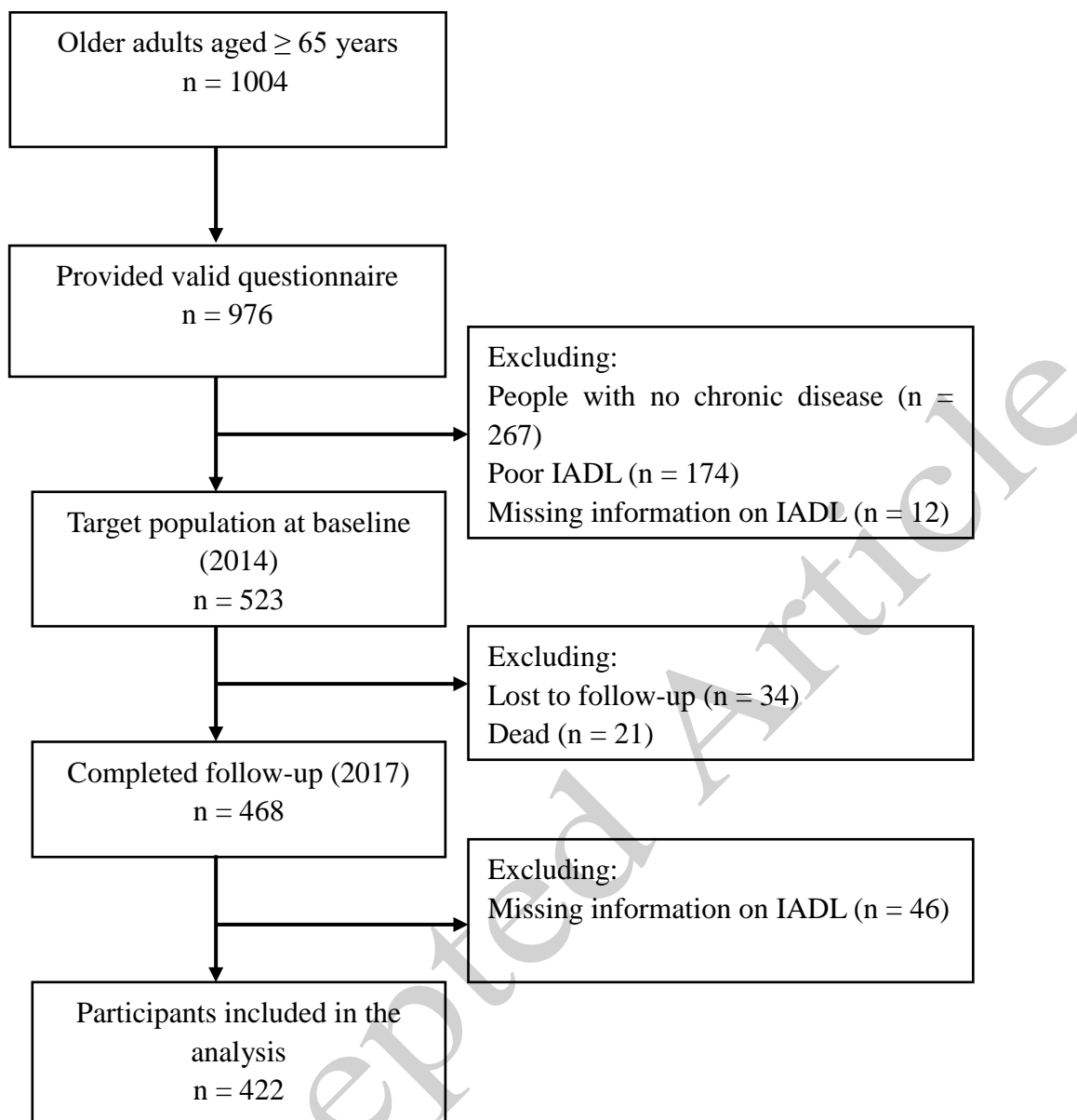
Figure 1: Flow chart of participants

Table 1: Baseline characteristics of the participants

Variables	Category	Total (n = 422)		Men (n = 190)		Women (n = 232)		*P*
		n	%	n	%	n	%	
Age (mean ± SD)		72.8 ± 6.1		72.7 ± 6.1		72.9 ± 6.1		0.680
Living status	Not alone	388	94.4	176	95.1	212	93.8	0.560
	Alone	23	5.6	9	4.9	14	6.2	
	Missing	11		5		6		
Exercise	Yes	254	62.1	115	63.2	139	61.2	0.686
	No	155	37.9	67	36.8	88	38.8	
	Missing	13		8		5		
Drinking	Yes	142	35.1	106	41.1	36	16.1	< 0.001
	No	262	64.9	74	58.9	188	83.9	
	Missing	18		10		8		
Smoking	Current	32	8.2	30	17.0	2	0.9	< 0.001
	Ex-smoker	99	25.4	93	52.5	6	2.8	
	Non-smoker	259	66.4	54	30.5	205	96.3	
	Missing	32		13		19		
ISI (mean ± SD)		16.5 ± 1.6		16.6 ± 1.5		16.4 ± 1.6		0.763
	Missing	45		15		30		
Number of diseases	1	235	55.7	103	54.2	132	56.9	0.581
	≥2	187	44.3	87	45.8	100	43.1	

SD: standard deviation; ISI: Index of Social Interaction.

Table 2: Baseline characteristics of participants per follow-up level of IADL

Variables	Category	Normal (n =359)		Low (n = 63)		χ^2/Z	P
		n	%	n	%		
Age (mean ± SD)		71.9 ± 5.4		78.5 ± 6.8		-6.995	< 0.001
Living status	Not alone	329	94.0	59	96.7	0.728	0.552
	Alone	21	6.0	2	3.3		
	Missing	9		2			
Exercise	Activity	227	65.0	27	45.0	8.739	0.003
	Inactivity	122	35.0	33	55.0		
	Missing	10		3			
Drinking	Yes	118	65.8	24	59.3	0.927	0.336
	No	227	34.2	35	40.7		
	Missing	14		4			
Smoking	Current	27	8.1	5	8.8	0.322	0.851
	Ex-smoker	83	24.9	16	28.1		
	Non-smoker	223	67.0	36	63.1		
	Missing	26		6			
ISI (mean ± SD)		16.6 ± 1.4		15.7 ± 1.9		-3.317	0.001
	Missing	41		4			
Number of diseases	1	198	55.2	37	58.7	0.278	0.598
	≥2	161	44.8	26	41.3		

IADL: instrumental activities of daily living; SD: standard deviation; ISI: index of social interaction.

Table 3: Baseline characteristics and follow-up IADL by gender

Variables	Category	Men						Women					
		Normal (n = 161)		Low (n = 29)		χ^2/Z	P		Normal (n = 198)		Low (n = 34)		χ^2/Z	P
		n	%	n	%				n	%	n	%		
Age (mean ± SD)		71.9 ± 5.5		77.1 ± 7.2		-3.686	< 0.001		71.8±5.3		79.6±6.3		-6.153	<0.001
Living status	Not alone	147	94.2	29	100.0	1.759	0.359		182	93.8	30	93.8	0.000	1.000
	Alone	9	5.8	0	0.0				12	6.2	2	6.2		
	Missing	5		0					4		2			
Exercise	Activity	102	65.4	13	50.0	2.268	0.132		125	64.8	14	41.2	6.777	0.009
	Inactivity	54	34.6	13	50.0				68	35.2	20	58.8		
	Missing	5		3					5		0			
Drinking	Yes	87	56.5	19	73.1	2.527	0.112		31	16.2	5	15.2	0.024	0.876
	No	67	43.5	7	26.9				160	83.8	28	84.8		
	Missing	7		3					7		1			
Smoking	Current	25	16.5	5	19.2	1.834	0.400		2	1.1	0	0.0	1.416	0.493
	Ex-smoker	77	51.0	16	61.6				6	3.3	0	0.0		
	Non-smoker	49	32.5	5	19.2				174	95.6	31	100.0		
	Missing	10		3					16		3			
ISI (mean ± SD)		14.9±2.3		13.8 ± 2.6		-2.080	0.038		14.7±2.6		13.1±2.4		-2.656	0.008
	Missing	15		0					26		4			
Number of diseases	1	88	54.6	15	51.7	0.085	0.770		110	55.6	22	64.7	0.991	0.320
	≥2	73	45.4	14	48.3				88	44.4	12	35.3		

IADL: instrumental activities of daily living; SD: standard deviation; ISI: index of social interaction.

Table 4: Logistic regression models of the association between baseline ISI and follow-up low IADL

Variables	Model 1					Model 2					Model 3				
	OR	95% CI			*P*	OR	95% CI			*P*	OR	95% CI			*P*
Total															
ISI	0.73	0.62	-	0.85	< 0.001	0.73	0.61	-	0.87	< 0.001	0.77	0.64	-	0.93	0.006
Age						1.18	1.12	-	1.24	< 0.001	1.17	1.11	-	1.23	<0.001
Exercise											1.67	0.86	-	3.26	0.130
Men															
ISI	0.77	0.61	-	0.98	0.035	0.79	0.61	-	1.02	0.070	0.80	0.60	-	1.07	0.131
Age						1.13	1.06	-	1.21	< 0.001	1.11	1.04	-	1.19	0.003
Exercise											1.21	0.44	-	3.28	0.714
Women															
ISI	0.69	0.56	-	0.85	0.001	0.66	0.51	-	0.86	0.002	0.71	0.55	-	0.93	0.011
Age						1.24	1.14	-	1.35	< 0.001	1.25	1.45	-	1.36	< 0.001
Exercise											2.56	0.98	-	6.65	0.054

IADL: instrumental activities of daily living; OR: odds ratio; CI: confidence interval; ISI: index of social interaction.