Title	Association between hand-grip strength and depressive symptoms: Locomotive Syndrome and Health Outcomes in Aizu Cohort Study (LOHAS).
Author(s)	Fukumori, Norio; Yamamoto, Yosuke; Takegami, Misa; Yamazaki, Shin; Onishi, Yoshihiro; Sekiguchi, Miho; Otani, Koji; Konno, Shin-ichi; Kikuchi, Shin-ichi; Fukuhara, Shun-ichi
Citation	Age and ageing (2015), 44(4): 592-598
Issue Date	2015-07
URL	http://hdl.handle.net/2433/202613
Right	This is a pre-copyedited, author-produced PDF of an article accepted for publication in 'Age and Ageing' following peer review. The version of record [Age Ageing (2015) 44 (4): 592-598. doi: 10.1093/ageing/afv013] is available online at: http://ageing.oxfordjournals.org/content/44/4/592; The full-text file will be made open to the public on 21 February 2016 in accordance with publisher's 'Terms and Conditions for Self-Archiving'.
Type	Journal Article
Textversion	author

Association between hand-grip strength and depressive symptoms; Locomotive Syndrome and Health Outcomes in the Aizu Cohort Study (LOHAS)

Norio Fukumori MD[1,2,8], Yosuke Yamamoto MD PhD[1,3,8], Misa Takegami RN PhD[4], Shin Yamazaki PhD[1], Yoshihiro Onishi PhC PhD[5], Miho Sekiguchi MD PhD[6], Koji Otani MD PhD[6], Shin-ichi Konno MD PhD[6], Shin-ichi Kikuchi MD PhD[6], Shunichi Fukuhara MD FACP PhD[1,7,]

1. Department of Healthcare Epidemiology, School of Public Health in the Graduate School of Medicine, Kyoto University, Kyoto, Japan

2. Community Medical Support Institute, Faculty of Medicine, Saga University, Saga, Japan

3. Institute for Advancement of Clinical and Translational Science, Kyoto University Hospital, Kyoto, Japan

4. Department of Preventive Medicine and Epidemiologic Informatics, National Cerebral and Cardiovascular Center, Suita, Japan

5. Institute for Health Outcomes and Process Evaluation Research (iHope International), Kyoto, Japan

6. Department of Orthopedic Surgery, Fukushima Medical University School of Medicine, Fukushima, Japan

7. Center for Innovation in Clinical Research, Fukushima Medical University, Fukushima, Japan

8. Fukumori and Yamamoto contributed equally to this article

Running title: Low hand-grip strength associates with depression

Key words: hand-grip strength; depressive symptoms; mental health; muscular weakness; older patients; population-based study

Key points:

1. The aim of this study is to evaluate the relationship between baseline hand-grip strength and subsequent risk of depressive symptoms at one year follow up.

2. Lower hand-grip strength was associated with depressive symptoms in both cross-sectional and longitudinal analysis.

3. The relationship between lower hand-grip strength and depressive symptoms was robust with adjustment for potential confounders.

Correspondence to: Prof. Shunichi Fukuhara

Department of Healthcare Epidemiology, School of Public Health in the Graduate School of Medicine, Kyoto University

Yoshida konoe-cho, Sakyo-ku, Kyoto 606-8501, Japan

Email: fukuhara.shunichi.6m@kyoto-u.ac.jp

TEL: +81-(0)75-753-4646

FAX: +81-(0)75-753-4644

ABSTRACT

Background

No study has examined the longitudinal association between hand-grip strength and mental health, such as depressive symptoms.

Objective

We investigated the relationship between baseline hand-grip strength and the risk of depressive symptoms.

Design

A prospective cohort study

Setting & Subjects

A prospective cohort study with a one-year follow-up was conducted using 4314 subjects from community-dwelling individuals aged 40-79 years old in 2 Japanese municipalities, based on the Locomotive Syndrome and Health Outcomes in Aizu Cohort Study (LOHAS, 2008-2010).

Method

We assessed baseline hand-grip strength standardized using national representative data classified by age and gender, and depressive symptoms at baseline and after the follow-up using the five-item version of the Mental Health Inventory (MHI-5).

Results

The 4314 subjects had a mean age of 66.3 years, 58.5% were women, and mean unadjusted hand-grip strength was 29.8 kg. Multivariable random-effect logistic regression analysis revealed that subjects with lower hand-grip

strength (per 1SD decrease) had higher odds of having depressive symptoms at baseline [Adjusted odds ratio (AOR) 1.15, 95% Confidence interval (CI) 1.06-1.24; *P* =0.001]. Further, lower hand-grip strength (per 1SD decrease) was associated with the longitudinal development of depressive symptoms after one year (AOR 1.13, 95% CI 1.01-1.27; *P* =0.036).

Conclusion

Using a large population-based sample, our results suggest that lower hand-grip strength, standardized using age and gender, is both cross-sectionally and longitudinally associated with depressive symptoms.

INTRODUCTION

A considerable number of older patients suffer from a decline in physical function due to age-related muscular weakness, the after effects of strokes, and degenerative neurological disorders such as Alzheimer disease [1, 2]. Previous studies reveal that patients with a decline in physical function are at great risk of falls, cardiovascular disease, and other complications [3-6]. Moreover, a decline in physical function is reportedly associated with mental health issues such as depression. For example, a recent study suggests a close relationship between depressive symptoms and activity of daily living in older persons, suggesting that a decline in physical function might predict the risk of having depressive symptoms [4].

However, the application of these findings in clinical settings requires the settling of two key issues: first, while a previous study demonstrated a longitudinal relationship between depressive symptoms and physical decline such as decrease in walking speed [5], the causal relationship between hand grip strength and depressive symptoms has not been well investigated. Second, because the previous studies used discrete and complicated definitions of physical function, such as the muscle strength of lower limbs and walking speed, interpretation of the results is not easy for general healthcare providers, indicating the need for a more convenient method of evaluating physical function in actual clinical settings.

Hand-grip strength, which is strongly correlated with systemic muscle strength, one of the promising candidate for the brief evaluation of physical function. Moreover, hand-grip strength is also used to predict future activities of daily life [7, 8]. While previous studies have suggested a cross-sectional association between hand-grip strength and depressive symptoms [9, 10], the longitudinal relationship between lower hand-grip

strength and the development of depressive symptoms has not been evaluated. In addition, assessment of the effect of hand-grip strength in the previous studies was done using models with insufficient adjustment, without normal population-based standardized values classified by age and sex [4, 11-15] .

Here, we investigated the relationship between the hand-grip strength, with adjustment using normal population-based standardized values, and both baseline depressive symptoms and the longitudinal development of depressive symptoms, using data from the Locomotive Syndrome and Health Outcome in Aizu Cohort Study (LOHAS) [16].

METHODS

Study Population

LOHAS (2008-2010) is a population-based cohort study conducted in two municipalities in Fukushima Prefecture, Japan [16]. The source population of LOHAS consisted of the general population of the region. Participations were limited to subjects aged 40-79 years who received annual health check-ups conducted by the local government in 2008-2010. The original aim of the study is to examine the relationship between locomotive syndrome and metabolic syndrome. Locomotive syndrome is a concept which denotes the vulnerable conditions in older patients due to functional decline in the locomotive organs [17]. All participants provided written informed consent, and the study protocol was approved by the institutional review board of Fukushima Medical University School of Medicine and Kyoto University Graduate School and Faculty of Medicine, Ethics Committee. Additional details on LOHAS sampling and study methods have been

previously described [16, 18].

Data Collection

The main variables evaluated were hand-grip strength and depressive symptoms. In LOHAS, hand-grip strength was measured using a digital dynamometer (Takei Scientific Instruments Co., Ltd, Japan). Strength was measured once for each hand in a monitored setting, with the forearm held parallel to the body in the standing position. In the present study, hand-grip strength was evaluated using the mean value of the data of both hands, unless only one of them was available. Then, to enable comparison of hand-grip strength regardless of sex and age, standardized hand-grip strength with adjustment for sex and age was calculated, using data from the Survey on Physical Strength and Physical Exercise Capability, which provided the national-representative mean and standard deviation of hand-grip strength classified by sex and age. In the main analysis, scores less than or equal to 50 and those more than 50 were defined as lower and higher hand-grip strength, respectively [19].

Depressive symptoms were assessed using the five-item version of the Mental Health Inventory (MHI-5), a 5-item questionnaire about depression which has been validated against the 20-item Zung Self-rating Depression Scale (ZSDS) and is considered highly reliable among the general population and patients with various psychiatric disorders[20]. In the MHI-5, a score of 60 or less suggests moderate or severe depression, which in our study is defined as having depressive symptoms.

Statistical Analysis

In the cross-sectional analysis, the relationship between standardized hand-grip strength, treated as a continuous variable, and odds of having depressive symptoms at baseline was examined by random-effect logistic regression analysis, with adjustment for age, sex, body mass index, smoking status, daily activities [moderate activities (e.g. carrying light loads) or severe activities (e.g. heavy lifting, digging, and climbing upstairs) more than once a week], and comorbid conditions (coronary artery disease, respiratory disease, stroke). Body Mass Index was assessed at the annual regular health check-up. Smoking status, daily activities, and comorbid conditions were assessed using the self-administered questionnaires. In the present study, random-effect models were employed to treat repeated measures between the same subjects at baseline (in 2008 and 2009), using the stata command xtlogit.

In the longitudinal analysis, assuming that lower hand-grip strength may predict the future risk of developing depressive symptoms, the relationship between lower standardized hand-grip strength at baseline (treated as a continuous variable) and development of depressive symptoms after one year was evaluated in subjects not having depressive symptoms at baseline using the random-effect logistic regression model described above, with adjustment for possible confounders aforementioned plus baseline MHI scores.

To examine the dose-dependency of the relationship, three categorical dummy variables were prepared according to quartile of score for standardized hand-grip strength from each participant. Random-effect logistic regression analysis was performed to evaluate the relationship between categorized standardized hand-grip strength at baseline and the odds of having depressive symptoms at baseline, and to evaluate subjects not having depressive symptoms at baseline between categorized standardized hand-grip strength at

baseline and the odds of developing depressive symptoms after one year. The first, second, and third quartiles were compared to the fourth quartile and results were expressed as an odds ratio of patients presenting depressive symptoms. Models were adjusted for the same possible confounders mentioned above. A test of linear trend across these four quartiles was performed using random-effect logistic regression models based on a previously reported method [21]. All analyses were performed using Stata SE version 13.1 (StataCorp LP, USA).

RESULTS

Of the 5347 participants enrolled in LOHAS, baseline data for standardized hand-grip strength and depressive symptoms were available for 4314 subjects (80.7%) (Figure 1). These 4314 subjects had a mean age of 66.3 years, 58.5% were women, and mean unadjusted hand-grip strength was 29.8 kg. Table 1 shows subject characteristics categorized by lower or higher average hand-grip strength, and characteristics of the 2479 (57.5%) of 4314 subjects with lower standardized hand-grip strength at baseline.

Cross-sectional relationship between depressive symptoms and hand-grip strength

Results showed that depressive symptoms were reported by 31.3% of patients with lower hand-grip strength and 25.8% of those with higher hand-grip strength ($P< 0.001$).

On multivariable random-effect logistic regression analysis, subjects with lower hand-grip strength (per 1SD decrease) had higher odds of having depressive symptoms at baseline [adjusted odds ratio (AOR) 1.15, 95%

confidence interval (CI) 1.06-1.24; *P* =0.001] (Table 2).

Compared with subjects in the fourth quartile of standardized hand-grip strength, those in the third, second, and first quartiles had significantly higher odds of having depressive symptoms at baseline, with AORs of 0.94, 1.20, and, 1.35, respectively (*P* for trend =0.005) (Figure 2).

.

Association between longitudinal development of depressive symptoms and hand-grip strength

From the total 4314 subjects, data regarding depressive symptoms collected one year after baseline were available for 2512. Of those, data from 1936 subjects shown not to have depressive symptoms at baseline were used for longitudinal analysis. The 1936 subjects had a mean age of 67.2 years, 60.2% were female, and 1039 subjects (53.6%) had a lower hand-grip strength at baseline. Results showed that 25.5% of subjects with a lower hand-grip strength and 20.4% of those with a higher hand-grip strength had developed depressive symptoms during follow-up (*P*=0.01). Multivariable random-effect logistic analysis revealed that subjects with lower hand-grip strength at baseline (per 1SD decrease) had higher odds of developing depressive symptoms after one year (AOR 1.13, 95% CI 1.01-1.27; *P*=0.036, Table 3).

Further, a significant dose-dependent relationship was observed between lower hand-grip strength and risk of developing depressive symptoms, with AORs for third, second, and first standardized hand-grip strength quartiles of 1.11, 1.17, and, 1.73, respectively (*P* for trend =0.005) (Figure 2).

DISCUSSION

In this study, we showed a significant relationship between hand-grip strength standardized with age and sex and depressive symptoms as assessed by a self-administered questionnaire (MHI-5), based on a large population-based sample. In particular, our results revealed that subjects with below-average standardized hand-grip strength were at greater risk of subsequently developing depressive symptoms, which suggests that lower hand-grip strength may be a causative factor in the development of depressive symptoms, independent from age and sex.

Results also revealed that the association was clearly defined when categorized standardized hand-grip strength were used for analysis, with the odds of presenting depressive symptoms at baseline increasing with decreasing standardized hand-grip strength in a dose-dependent manner. Further, this relationship was also observed between categorized standard hand-grip strength and the longitudinal development of depressive symptoms one year after baseline. Results from the present study were generalized through the use of a large population-based sample of older subjects. Additionally, the positive results, standardized using the national data may strengthen reliability of our main results.

A number of studies have identified an association between lower physical function, assessed using many indices such as the muscle strength of lower limbs, walking speed and self-perceived functional decline, and depressive symptoms[22, 23]. A recent study suggests a bidirectional association between walking speed and depressive symptoms, but most studies investigated merely cross-sectional relationships [23]. To our knowledge this is the first study to examine a longitudinal relationship between baseline hand-grip strength and the development of depressive symptoms.

In the present study, we focused on hand-grip strength as representative of general physical function. Rantanen et al. evaluated the association between hand grip strength and the strength of other muscle functions, and reported correlation coefficients with elbow flexion strength ($r = 0.672$), knee extension strength ($r = 0.514$), and trunk extension strength ($r = 0.541$) which indicate an approximation of total body muscle strength [8, 12]. Hand-grip strength may thus serve as useful and simple measure of total body muscle function.

The longitudinal analysis in the present study showed that lower hand-grip strength, representing lower motor functions, is associated with the future risk of worsening mental health. One cohort study have shown that patients treated for depressive symptoms who have lower hand-grip strength or felt physical handicaps remained in a depressive mood for several years [24]. This finding suggests that lower hand-grip strength may have had a direct effect on the decreased metal health of the participants. Growing evidences suggests that lower hand-grip strength is closely associated with decreased physical quality of life (QOL), which would in turn explain how hand-grip strength, representing states of motor functions, affects mental health via physical QOL. Contrarily, patients with depressive symptoms might be likely to develop lower hand-grip strength based on the possible hypothesis that depression might cause decline in systemic physical functioning. Demakakos et al. revealed a bidirectional association between walking speed and depressive symptoms, supporting the speculation the association between hand-grip strength and depressive symptoms was bidirectional [23].

Previous studies have shown that a significant proportion of community-dwelling residents have depressive symptoms [25, 26]. However, healthcare providers other than psychiatrists are not familiar with identifying

241 depression, and many patients remain undiagnosed and undertreated. In general, most questionnaires used to
242 screen for depressive symptoms consist of items which are perceived as threatening by psychologically
243 distressed patients, and thus likely to affect doctor-patient relationship. This highlights the difficulties of
244 managing depressed patients in local settings. Given that hand-grip strength can be measured even at routine
245 health check-ups, we speculate that hand-grip strength might be a candidate of predictors when developing
246 clinical prediction rules to detect depressive symptoms. Further investigations are needed to apply the result
247 into actual clinical settings.
248 Several limitations of our study warrant mention. Longitudinal analysis in the present study might have been
249 biased by the exclusion of 34.6% of subjects from follow-up. We compared the baseline characteristics (age,
250 sex, and depressive symptoms) between patients with follow-up and those lost to follow-up, but there have
251 been no remarkable differences. Duration of the follow-up period was only one year, and we did not examine
252 the long-term relationship between hand-grip strength and depressive symptoms. Although our results indicate
253 that depressive symptoms are sufficiently measured by MHI-5, assessment using this method does not fulfill
254 the criteria of definitive diagnosis of depression. Data on details of socioeconomic status were not recorded in
255 the present study, so we could not take this potential confounding factor into account in the multivariable
256 analyses. In addition, our study was limited to a Japanese population, and the extrapolation of our findings to
257 other countries requires further investigation. Although the results reveal a longitudinal relationship between
258 hand-grip strength and depressive symptoms, the test performance of screening depressive symptoms using
259 hand-grip strength cannot be assessed in the present study. Finally, as a general limitation of observational

studies, we were unable to adjust for unknown confounding factors highly associated with the investigated relationship.

In conclusion, our results from a large population-based sample show a significant epidemiological association between hand-grip strength and both depressive symptoms at baseline and the longitudinal development of depressive symptoms.

ACKNOWLEDGEMENTS

The authors wish to thank the staff of the public offices of Tadami and Minami-Aizu for their assistance in locating participants and scheduling examinations. The authors are also grateful to the participants of the LOHAS. All authors have indicated that no financial conflicts of interest were present.

REFERENCES

1. Mehta KM, Yaffe K, Covinsky KE. Cognitive impairment, depressive symptoms, and functional decline in older people. J Am Geriatr Soc. 2002;50(6):1045-50.

2. Russo A, Onder G, Cesari M, Zamboni V, Barillaro C, Capoluongo E, et al. Lifetime occupation and physical function: a prospective cohort study on persons aged 80 years and older living in a community. Occup Environ Med. 2006;63(7):438-42.

3. Landi F, Liperoti R, Russo A, Giovannini S, Tosato M, Capoluongo E, et al. Sarcopenia as a risk factor for falls in elderly individuals: results from the ilSIRENTE study. Clin Nutr. 2012;31(5):652-8.

4. Yanagita M, Willcox BJ, Masaki KH, Chen R, He Q, Rodriguez BL, et al. Disability and depression: investigating a complex relation using physical performance measures. Am J Geriatr Psychiatry. 2006;14(12):1060-8.

5. Brown WJ, Ford JH, Burton NW, Marshall AL, Dobson AJ. Prospective study of physical activity and depressive symptoms in middle-aged women. Am J Prev Med. 2005;29(4):265-72.

6. Studenski S, Perera S, Patel K, Rosano C, Faulkner K, Inzitari M, et al. Gait speed and survival in older adults. JAMA. 2011;305(1):50-8.

7. Rantanen T, Guralnik JM, Foley D, Masaki K, Leveille S, Curb JD, et al. Midlife hand grip strength as a predictor of old age disability. JAMA. 1999;281(6):558-60.

8. Rantanen T, Harris T, Leveille SG, Visser M, Foley D, Masaki K, et al. Muscle strength and body mass index as long-term predictors of mortality in initially healthy men. J Gerontol A Biol Sci Med Sci.

2000;55(3):M168-73.

9. Gale CR, Sayer AA, Cooper C, Dennison EM, Starr JM, Whalley LJ, et al. Factors associated with symptoms of anxiety and depression in five cohorts of community-based older people: the HALCyon (Healthy Ageing across the Life Course) Programme. Psychol Med. 2011;41(10):2057-73.

10. van Milligen BA, Lamers F, de Hoop GT, Smit JH, Penninx BW. Objective physical functioning in patients with depressive and/or anxiety disorders. J Affect Disord. 2011;131(1-3):193-9.

11. Bohannon RW. Hand-grip dynamometry predicts future outcomes in aging adults. J Geriatr Phys Ther. 2008;31(1):3-10.

12. Rantanen T, Volpato S, Ferrucci L, Heikkinen E, Fried LP, Guralnik JM. Handgrip strength and cause-specific and total mortality in older disabled women: exploring the mechanism. J Am Geriatr Soc. 2003;51(5):636-41.

13. Ling CH, Taekema D, de Craen AJ, Gussekloo J, Westendorp RG, Maier AB. Handgrip strength and mortality in the oldest old population: the Leiden 85-plus study. CMAJ. 2010;182(5):429-35.

14. Puh U. Age-related and sex-related differences in hand and pinch grip strength in adults. Int J Rehabil Res. 2009;33(1):4-11.

15. Massy-Westropp NM, Gill TK, Taylor AW, Bohannon RW, Hill CL. Hand Grip Strength: age and gender stratified normative data in a population-based study. BMC Res Notes. 2011;4:127.

16. Otani K, Takegami M, Fukumori N, Sekiguchi M, Onishi Y, Yamazaki S, et al. Locomotor dysfunction and risk of cardiovascular disease, quality of life, and medical costs: design of the Locomotive

Syndrome and Health Outcome in Aizu Cohort Study (LOHAS) and baseline characteristics of the study population. J Orthop Sci. 2012;17(3):261-71.

17. Nakamura K. A "super-aged" society and the "locomotive syndrome". J Orthop Sci. 2008;13(1):1-2.

18. Ono R, Yamazaki S, Takegami M, Otani K, Sekiguchi M, Onishi Y, et al. Gender difference in association between low back pain and metabolic syndrome: locomotive syndrome and health outcome in Aizu cohort study (LOHAS). Spine (Phila Pa 1976). 2012;37(13):1130-7.

19. The survey on the physical strength and physical exercise capability [database on the Internet]2008. Available from: http://www.e-stat.go.jp/SG1/estat/Xlsdl.do?sinfid=000004849615

20. Yamazaki S, Fukuhara S, Green J. Usefulness of five-item and three-item Mental Health Inventories to screen for depressive symptoms in the general population of Japan. Health Qual Life Outcomes. 2005;3:48.

21. Hu F, Sigal R, Rich-Edwards J, Colditz G, Solomon C, Willett W, et al. Walking compared with vigorous physical activity and risk of type 2 diabetes in women: a prospective study. JAMA. 1999;282(15):1433-9.

22. Buigues C, Padilla-Sanchez C, Fernandez Garrido J, Martinez RN, Ros VR, Cauli O. The relationship between depression and frailty syndrome: a systematic review. Aging Ment Health. 2014:1-11.

23. Demakakos P, Cooper R, Hamer M, de Oliveira C, Hardy R, Breeze E. The bidirectional association between depressive symptoms and gait speed: evidence from the English Longitudinal Study of

Ageing (ELSA). PLoS One. 2013;8(7):e68632.

24. van Milligen BA, Vogelzangs N, Smit JH, Penninx BW. Physical function as predictor for the persistence of depressive and anxiety disorders. J Affect Disord. 2011;136(3):828-32.

25. Stordal E, Mykletun A, Dahl AA. The association between age and depression in the general population: a multivariate examination. Acta Psychiatr Scand. 2003;107(2):132-41.

26. Kaneko Y, Motohashi Y. Male gender and low education with poor mental health literacy: a population-based study. J Epidemiol. 2007;17(4):114-9.

FIGURE LEGENDS

Figure 1 Flow chart of the study

Figure 2 Odds ratio of depressive symptoms (a) at baseline, and (b) after one-year follow-up, by quartile of standardized hand-grip strength

351 **TABLES**

352 **Table 1.** Characteristics of all subjects by hand grip strength in cross-sectional study

	Total (n=4314)	Hand grip strength High (n=1835)	Low (n=2479)
Age, mean ± SD, years	66.3 ± 9.0	65.5 ±9.0	66.9 ±8.9
Age groups			
40 - 49, %	6.1	7.0	5.4
50 - 59, %	14.6	15.6	13.8
60 - 69, %	36.3	37.7	35.3
70 - 79, %	43.0	40.0	45.5
Sex, female, (%)	58.5	55.7	60.6
Hand grip strength, mean ± SD, kg	29.8 ± 9.9	35.5 ± 9.5	25.6 ± 7.9
Mental Statement			
MHI, mean ± SD	74.7 ±18.43	76.4 ± 17.7	73.5±18.7
Depressive symptoms, %	29.0	25.8	31.3
Body mass index, mean ± SD	23.8 ± 3.2	24.2 ± 3.0	23.5 ± 3.2
Smoking status			
Current smoker, %	13.6	14.0	13.3
ex-smoker, %	21.7	23.5	20.3
Moderate or severe activities more than once a week, %	73.3	79.6	68.6
Comorbidities			
Heart disease, (%)	6.8	6.2	7.3
Respiratory disease, (%)	3.8	4.0	3.7
Stroke, (%)	4.2	3.3	4.8

353

354 **Table 2.** Odds ratio of depressive symptoms by hand grip strength, age, sex, and comorbidities in

355 cross-sectional analysis

	Fully-adjusted model				Minimally-adjusted model			
	AOR	95% CI		*P* value	AOR	95% CI		*P* value
Hand grip strength (per 1SD decrease)	1.15	1.06	1.24	0.001	1.16	1.08	1.25	<0.001
Age categories								
40 – 49	Ref.				Ref.			
50 – 59	1.18	0.73	1.93	0.502	1.35	0.88	2.07	0.175
60 – 69	1.39	0.89	2.19	0.149	1.50	1.02	2.23	0.042
70 – 79	1.56	0.99	2.46	0.053	1.67	1.13	2.46	0.010
Sex								
Male	Ref.				Ref.			
Female	1.41	1.09	1.82	0.009	1.30	1.09	1.53	0.003
Body mass index (per 1 unit increase)	1.00	0.97	1.03	0.954				
Current smoker (vs. never-smoker)	1.24	0.90	1.71	0.183				
Ex-smoker (vs. never-smoker)	1.01	0.76	1.35	0.949				
Moderate or severe activities more than once a week (vs. no)	0.96	0.85	1.07	0.425				
Comorbidities (vs. none)								
Heart disease	1.21	0.85	1.72	0.292				
Respiratory disease	1.66	1.06	2.58	0.026				
Stroke	1.09	0.70	1.69	0.707				

AOR; adjusted odds ratio, CI; confidence interval

Age and sex were adjusted in the minimally-adjusted model

356

357

358

Table 3. Odds ratio of depressive symptoms at 1 year by hand grip strength, age, sex, and comorbidities in longitudinal analysis.

	Fully-adjusted model				Minimally-adjusted model			
	AOR	95% CI		*P* value	AOR	95% CI		*P* value
Hand grip strength (per 1SD decrease)	1.13	1.01	1.27	0.036	1.14	1.01	1.28	0.035
Age categories								
40 – 49	Ref.				Ref.			
50 – 59	3.45	1.06	11.28	0.04	3.65	1.17	11.36	0.025
60 – 69	5.81	1.82	18.60	0.003	5.92	1.96	17.89	0.002
70 – 79	9.37	2.82	31.17	<0.001	9.99	3.20	31.15	<0.001
Sex								
Male	Ref.				Ref.			
Female	1.76	1.20	2.57	0.004	1.88	1.41	2.52	<0.001
Body mass index (per 1 unit increase)	1.03	0.99	1.08	0.111				
Current smoker (vs. never-smoker)	1.38	0.86	2.23	0.183				
Ex-smoker (vs. never-smoker)	1.07	0.70	1.61	0.764				
Moderate or severe activities more than once a week (vs. no)	1.01	0.85	1.21	0.888				
Comorbidities (vs. none)								
Heart disease	1.35	0.83	2.18	0.226				
Respiratory disease	1.51	0.81	2.82	0.190				
Stroke	0.70	0.37	1.31	0.263				

AOR; adjusted odds ratio, CI; confidence interval

Age and sex were adjusted in the minimally-adjusted model