Lower Grip Strength and Insufficient Physical Activity Can Increase Depressive Symptoms Among Middle-Aged and Older European Adults

Han Zheng
Shandong University
Chongqi Jia (jiachongqi@sdu.edu.cn)
Shandong University

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Abstract

Objectives: The present study aimed to explore the interaction between grip strength and physical activity on depression, and investigate the association of physical activity with the change in depression by different grip strength groups among middle-aged and older European adults.

Methods: A total of 13936 participants aged 50 years or older from the Survey of Health, Ageing and Retirement in Europe 2007-2017 were included in this study. Group-based trajectory modeling was used to identify the low, middle and high group of grip strength by gender. Generalized estimated equations were fitted to analyze the interaction effect.

Results: Significant interactions between grip strength group and physical inactivity were found ($O_{\text{interaction}=}16.70$, $p<0.001$). Significant interactions between physical inactivity and time on depression were identified in low ($b_{\text{interaction}=}22.15$, $p<0.001$) and moderate ($j_{\text{interaction}=}22.85$, $p<0.001$) grip strength, but a similar result was not found in high grip strength ($e_{\text{interaction}=}3.20$, $p=0.526$). Participants in the physical inactivity group had higher depression scores in the low and moderate grip strength group.

Conclusions: Grip strength and physical inactivity have interaction with depression. Lower grip strength and insufficient physical activity could increase depressive symptoms. People with lower grip strength and physical inactivity should pay special attention to the prevention of depression.

Introduction

Depression as the leading cause of mental health disorder burden globally affects an estimated 300 million people worldwide[1]. The increasing aging population and elongated life expectancy make a great challenge to humans[2]. Against the background of the abovementioned, highly prevalent late-life depression dramatically reduces the quality of life in older people[3]. Long-term depression increases the risk of morbidity[4], mortality[5] and also the frequency of health care services use[6]. Multitudinous factors, including dysfunctional cognitions, stressful life events, health status and interpersonal dysfunction, could increase the risk of depression[7,8]. Besides, it is reported that handgrip strength and physical activity were related to mental health[9,10].

Handgrip strength is a well-established measure of physical performance/muscle strength that has been widely used in an observational cohort study and clinical settings[11,12]. Numerous pieces of literature have shown that handgrip strength is positively associated with depressive symptoms, which means good handgrip strength could prevent the incidence of depression [9,13]. Evidence of handgrip strength existing sex-related differences and declined by aging has been clarified[14]. However, up to now, the knowledge of the definition of good grip strength is still lacking[15]. Most studies group handgrip strength using the percentage method based on data distribution[16]. Although the above studies have taken the influences of gender and age on grip strength into account, the time effect on grip strength for the same person is ignored. Engagement in physical activity presents the psychological benefit in late life [17]. However, to our knowledge, little information is now available for the combined effect of grip strength and physical activity on depression in older people, and whether the effect of physical with long-term change on depression differentiated by grip strength groups.

Hence, we conducted a prospective study with a large, multinational cohort derived from the Survey of Health, Ageing and Retirement in Europe (SHARE) 2005–2017 to (1)identify the gender-specific trajectories of grip strength using group-based trajectories (GBTM)[18]; (2) explore the joint effect of grip strength trajectory groups and physical activity and (3) investigate the association of physical activity with a long-term change of depression according to grip strength groups.

Methods

Study population

Data were obtained from the SHARE, which was biennial longitudinal research aimed at assessing the population aged 50 or older across European countries by using probability-based sampling. Details about sampling methodology could be found in the published official article[19]. The information of this survey concerned health, socio-economic status, and social and family networks. Six waves (1, 2, 4, 5, 6, 7) and one retrospective life history wave (3) were conducted ever since 2004. Since the second wave, SHARE has successively incorporated more European countries such as Belgium, Czech Republic, Poland, Ireland and so on based on the first wave. Thus, we analyzed data from five-panel waves of the SHARE but excluding the first and third waves in the present study. SHARE was reviewed and approved by the ethics committee of the University of Mannheim and the ethics council of the Max Planck Society. We confirm that all methods were performed in accordance with the relevant guidelines and regulations, and informed consent was obtained from all participants and their legal guardians.

A total of 37152 people participated in the second wave which carried out in 2006, The exclusion criteria are as follows: (1) excluding those who participated less than three waves during the following years (n = 17021); (2) excluding those with cancer, Parkinson’s disease, Alzheimer’s disease and stroke at any survey may affect handgrip strength measurement (n = 1353); (3) excluding participants with missing data of alcohol intake, smoking status, family economic level, physical activity, European depression scale, grip strength and cognitive function (n = 1087); (4) excluding individuals with depression at baseline (wave 2) so that avoiding causing reverse causality (n = 3728). Ultimately, 13936 individuals were left in this study. The selection process of the study population was shown in Fig. 1.

Depression

Depression was evaluated using the European depression (EURO-D) scale. The scale is a 12-item binary scale including the following symptoms: depression, pessimism, suicidality, guilty, sleep, irritability, fatigue, appetite, interests, enjoyment, concentration and tearfulness, which has been validated by European Depression Concerted Action Project[20]. THE total EURO-D scale ranged from 0 to 12 with a score above three representing clinically depression.

Physical inactivity

Physical activity was assessed by asking two questions about how often to engage in moderate and vigorous-intensity physical activity in daily life, respectively. The following response options were given: more than once a week, once a week, one to three times a month and hardly ever or never. Participants who reported less than ‘one to three times a month’ for either moderate or vigorous-intensity physical activity were defined as physical inactivity[21].

Grip strength

Grip strength was measured using a Smedley handheld dynamometer (100 kg)[22]. Participants were requested to sit or stand while keeping the upper arms tight against the trunk with their elbows at a 90° angle and then squeeze the handles as hard as possible for 5 s. Two alternate measures from their right and left hands were performed, the highest value of four measures in each survey wave was used in the present study. Due to the lack of a standard grouping method for grip strength until now, we used GBTM to explore a suitable group according to genders based on the panel data. The specific grouping method could be found in the supplementary file of S-figure 1 and 2.

Covariates

Covariates in this study were acquired from the questionnaire, including age, gender (male/female), European region (central, northern, southern and western Europe), married status (married, living with a spouse/other married status such as divorced, widow), education (primary/secondary/tertiary education), employment status (employed/retired/unemployment), family economic level, smoking status (never, ever and current smoker), alcohol intake (whether drinking exceed two glasses), heart attack (yes/no), hypertension (yes/no), hyperlipidemia (yes/no), diabetes (yes/no), mobility limitation (yes/no), body mass index (BMI) and cognitive function. Education was categorized based on the International Standard Classification of Education[23]. The family economic level was determined by one question: “Is your household able to make ends meet?” The answers included easily, fairly easily, with some difficulty and with great difficulty. BMI was calculated as weight in kilograms divided by height in meters squared. Cognitive function was assessed from four domains: time orientation, memory, verbal fluency and numeracy[24,25]. The scores of each domain ranged from 0 to 5, 0 to 20, 0 to 100 and 0 to 5, respectively. To avoid the proportion of memory and fluency accounted too high, we convert these two indexes into decimal systems. The sum of the above scores was used to assess cognitive function.

Statistical analysis

All statistical analyses were conducted using STATA version 16.0 (Stata Corp, College Station, Texas). GBTM was used to identify low, moderate and high grip strength groups of individuals following similar patterns of grip strength according to genders. Data was given in the form of means and standard deviations (SDs) for continuous variables or as percentages for categorical variables. One-way analysis of variance (ANOVA) was used to examine the difference of means for continuous variables with normal distribution; otherwise, the Kruskal-Wallis test was used. Pearson’s $\chi 2$ test was performed to compare the distribution of the categorical variables between the three grip strength groups. Multiplicative interaction was assessed through the grip strength-physical inactivity interaction term in the generalized estimated equation (GEE) model. After determining the joint effect of grip strength and exercise on depression, time-variable was interacted with physical inactivity according to grip strength groups to identify the independent effect of exposure on the change of depression over time. The depression was treated as a continuous variable in all GEE models. The independent working correlation structure was chosen in the GEE analysis.

All of the GEE models were adjusted for the potential confounders including age, gender, European region, married status, education, employment status, family economic level, smoking status, alcohol intake, heart attack, hypertension, hyperlipidemia, diabetes, mobility limitation, BMI and cognitive function. A two-tailed *P* value less than 0.05 was recognized as statistically significant.

Results

Baseline characteristics of participants

A total of 2860 participants in the low grip strength group, 7518 in the moderate grip strength group and 3558 in the high grip strength group were included in this study. The gender-specific grip strength groups explored by GBTM were presented in **Supplementary Fig. 1**. The mean follow-up time was 7.82 years. The baseline characteristics of participants across the three grip strength groups were shown in Table 1. Individuals with high grip strength tended to be younger (mean age was 58.25 years old), male (51.07%), married (79.79%), have secondary education (56.75%), higher family economic level, higher alcohol intake, have higher BMI (average BMI was 26.89 kg/m^2) and cognitive function (average score was 15.25). Participants with low grip strength were more likely to live in southern Europe (35.98%), be retired (68.39%), never smoking (41.5%), have a heart attack (12.94%), hypertension (39.37%), hyperlipidemia (24.97%), diabetes (14.23%), mobility limitation (58.81%) and be physical inactivity (9.44%). The average depression scores increased over time, but this trend in the low and moderate grip strength group was more obvious than in the high grip strength group.

Table 1
Baseline characteristics of participants according to grip strength groups

	Low grip strength (n = 2860)	Middle grip strength (n = 7518)	High grip strength (n = 3558)	*P*
Age	71.01 ± 8.41	63.39 ± 7.46	58.25 ± 5.52	< 0.001*
Gender (%)				
Female	51.75	51.36	48.93	0.031*
Region (%)				
Central Europe	29.34	32.92	31.84	< 0.001*
Northern Europe	12.97	17.23	24.31	
Southern Europe	35.98	24.93	16.92	
Western Europe	21.71	24.93	26.93	
Married Status (%)				
Married, living with a spouse	68.99	76.24	79.79	
Education (%)				
Primary Education	45.10	23.97	14.73	< 0.001*
Secondary Education	39.34	52.53	56.75	
Tertiary Education	15.56	23.5	28.53	
Employment Status (%)				
Employed	20.07	17.84	15.88	< 0.001*
Retired	68.39	48.87	26.34	
Unemployed	11.54	33.29	57.79	

Abbreviations: BMI, body mass index; EURO-D, European depression scale
[a] One-way analysis of variance
[b] Chi-square test
[c] Kruskal-Wallis test

	Low grip strength (n = 2860)	Middle grip strength (n = 7518)	High grip strength (n = 3558)	*P*
Family economic level (%)				
With great difficulty	12.52	8.27	5.62	< 0.001*
With some difficulty	29.93	25.50	22.26	
Fairly easily	33.81	34.76	35.08	
Easily	23.74	31.47	37.04	
Smoke status (%)				
Never smoking	41.50	32.50	26.73	< 0.001*
Ever smoker	25.10	28.47	31.82	
Current smoker	33.39	39.04	41.46	
Alcohol intake (%)				
More than recommended level	13.57	20.92	26.45	< 0.001*
Heart attack (%)	12.94	8.42	5.23	< 0.001*
Hypertension (%)	39.37	32.65	24.93	< 0.001*
Hyperlipidemia (%)	24.97	21.71	17.06	< 0.001*
Diabetes (%)	14.23	8.95	4.53	< 0.001*
Mobility limitation (%)	53.81	33.00	23.72	< 0.001*
Physical inactivity (%)	9.44	3.98	2.53	< 0.001*
BMI	26.65 ± 4.35	26.58 ± 4.11	26.89 ± 4.68	< 0.001*

Abbreviations: BMI, body mass index; EURO-D, European depression scale

[a] One-way analysis of variance

[b] Chi-square test

[c] Kruskal-Wallis test

	Low grip strength (n = 2860)	Middle grip strength (n = 7518)	High grip strength (n = 3558)	*P*
Cognition	12.6 ± 2.88	14.28 ± 2.53	15.25 ± 2.36	< 0.001*
EURO-D score				
wave 2	1.34 ± 1.07	1.17 ± 1.05	1.11 ± 1.05	< 0.001*
wave 4	2.19 ± 1.98	1.73 ± 1.73	1.52 ± 1.62	< 0.001*
wave 5	2.27 ± 2.10	1.68 ± 1.78	1.45 ± 1.56	< 0.001*
wave 6	2.50 ± 2.25	1.81 ± 1.87	1.56 ± 1.71	< 0.001*
wave 7	2.55 ± 2.28	1.85 ± 1.86	1.47 ± 1.61	< 0.001*

Abbreviations: BMI, body mass index; EURO-D, European depression scale

[a] One-way analysis of variance

[b] Chi-square test

[c] Kruskal-Wallis test

The joint effect of grip strength and physical inactivity

Results of multiplicative interaction between grip strength and physical inactivity were presented in Table 2. We also conducted a joint test to assess the association of grip strength and physical inactivity with depression. A significant interaction effect between grip strength and physical inactivity with depression was identified (joint test: $x^2{}_{interaction=}$16.70, df = 2, *P* < 0.001).

Table 2
Interactions between grip strength and physical activity

EURO-D		*β (95%CI)*	*P*
Grip strength	Middle	-0.01(-0.09-0.08)	0.844
	High	0.04(-0.08-0.16)	0.485
Physical inactivity	Inactivity	0.84(0.65–1.03)	< 0.001*
Grip strength × Physical inactivity	Middle × Inactivity	-0.45(-0.70–0.20)	< 0.001*
	High × Inactivity	-0.60(-0.96–0.23)	0.001
Abbreviations: *β*, coefficient, *CI*, confidence interval			
Adjusted for age, gender, European region, married status, education, employment status, family economic level, smoking status, alcohol intake, heart attack, hypertension, hyperlipidemia, diabetes, mobility limitation, body mass index and cognitive function			

Impact of physical inactivity according to grip strength groups

Table 3 summarized the result of physical inactivity interacts with time according to different grip strength groups. Significant interactions between physical inactivity and time with depression were identified in both low (joint test: $x^2{}_{interaction=}25.15$, df = 4, $P < 0.001$) and moderate (joint test: $x^2{}_{interaction=}22.85$, df = 4, $P < 0.001$) grip strength group. As shown in Fig. 2A, B, the increasing rate of depression was faster in physical inactivity than in the physical activity group. Compared to the physical activity group, participants in the physical inactivity group were positively associated with depression scores at wave 4 ($\beta = 0.79$, $P < 0.001$), 5 ($\beta = 0.85$, $P < 0.001$), 6 ($\beta = 0.93$, $P < 0.001$) and 7 ($\beta = 0.60$, $P = 0.006$) except at baseline ($\beta = 0.12$, $P = 0.253$) in low grip strength group. For moderate grip strength, participants in physical inactivity group had higher depression scores at wave 6 ($\beta = 0.54$, $P = 0.003$), 7 ($\beta = 0.84$, $P < 0.001$) but no significant differences were found in baseline (β=-0.02, p = 0.828), wave 4 ($\beta = 0.28$, $P = 0.066$) and 5 ($\beta = 0.24$, $P = 0.164$). No significant interaction between physical inactivity and time with depression were identified in high (joint test: $x^2{}_{interaction=}3.20$, df = 4, $P = 0.526$) grip strength group (Fig. 2C).

Table 3

Interactions between time and physical activity according to grip strength group

Grip strength	EURO-D		*β (95%CI)*	*P*
Low	Time	wave 4	0.85(0.68–1.01)	< 0.001*
		wave 5	0.94(0.74–1.13)	< 0.001*
		wave 6	1.00(0.82–1.17)	< 0.001*
		wave 7	1.16(0.95–1.38)	< 0.001*
	Physical inactivity	Inactivity	0.12(-0.08-0.32)	0.253
	Time × Physical inactivity	wave 4×Inactivity	0.68(0.25–1.10)	0.002*
		wave 5×Inactivity	0.73(0.29–1.18)	0.001*
		wave 6×Inactivity	0.82(0.41–1.23)	< 0.001*
		wave 7×Inactivity	0.48(0.01–0.96)	0.047*
Middle	Time	wave 4	0.55(0.46–0.65)	< 0.001*
		wave 5	0.65(0.55–0.75)	< 0.001*
		wave 6	0.62(0.53–0.71)	< 0.001*
		wave 7	0.59(0.48–0.69)	< 0.001*
	Physical inactivity	Inactivity	-0.02(-0.20-0.16)	0.828
	Time × Physical inactivity	wave 4×Inactivity	0.30(-0.05-0.66)	0.093
		wave 5×Inactivity	0.26(-0.11-0.64)	0.168
		wave 6×Inactivity	0.56(0.18–0.94)	0.004*
		wave 7×Inactivity	0.87(0.47–1.26)	< 0.001*
High	Time	wave 4	0.56(0.32–0.81)	< 0.001*
		wave 5	0.48(0.31–0.66)	< 0.001*
		wave 6	0.59(0.35–0.84)	< 0.001*
		wave 7	0.56(0.31–0.80)	< 0.001*
	Physical inactivity	Inactivity	0.15(-0.17-0.48)	0.364
	Time × Physical inactivity	wave 4×Inactivity	0.22(-0.37-0.81)	0.460

Abbreviations: *β*, coefficient, *CI*, confidence interval

Adjusted for age, gender, European region, married status, education, employment status, family economic level, smoking status, alcohol intake, heart attack, hypertension, hyperlipidemia, diabetes, mobility limitation, body mass index and cognitive function

Grip strength	EURO-D		β (95%CI)	P
		wave 5×Inactivity	0.69(-0.25-1.63)	0.150
		wave 6×Inactivity	0.22(-0.54-0.98)	0.566
		wave 7×Inactivity	-0.12(-0.71-0.48)	0.703
Abbreviations: *β*, coefficient, *CI*, confidence interval				
Adjusted for age, gender, European region, married status, education, employment status, family economic level, smoking status, alcohol intake, heart attack, hypertension, hyperlipidemia, diabetes, mobility limitation, body mass index and cognitive function				

Discussion

This large longitudinal study documented two major findings. First, multiplicative interaction was found between grip strength and physical inactivity on depressive symptoms. Second, the significant difference in the change of depressive symptoms between physical inactivity and physical activity was found in the low and moderate grip strength group, but no significant difference was found in the high grip strength group.

The interaction effect indicated that depression risk in people of physical inactivity with declined grip strength would be higher than that in individuals performing enough physical activity and with good grip strength. Previous cohort studies have reported the protective benefits of grip strength for incident depression[9,26]. The relationship between physical activity and depression has also been well documented[27,28]. The results of the present study support those of previous study results. Grip strength is commonly used to capture muscular strength. Lack of muscular strength may affect myokines released into the circulatory systems, which could protect against the risk of depression [29]. Besides, muscular strength is related to sarcopenia[30], functional limitations and disabilities[31]. People with lower grip strength may have poorer health conditions. A decline in physical function might predict the risk of having mental illness [32]. Continuous engagement in physical activity could make the elderly experience more positive leisure activities and enough social support, which results in higher psychological well-being and finally reduces depression[33]. Low grip strength and physical inactivity may have a combined effect on depression, both biologically and psychosocially, that is greater than each effect.

Physical inactivity was related to the change of depression in the low and moderate grip strength groups. However, this association was not found in the high grip strength group. A study from a British birth cohort revealed that increased levels of physical activity could prevent a decline in grip strength[34]. Randomized controlled trials have shown that physical activity reduces depressive symptoms in older adults[35]. Because physical activities can change the central norepinephrine activity temporarily, decrease the hypothalamopituitary–adrenocortical axis, and increase the secretion of beta-endorphins which have positive effects on mood [36]. Besides, physical activity may increase hippocampal volume and neurogenesis levels, as well as adjust the imbalance between anti- and proinflammatory and oxidant markers to play an antidepressant role[28]. Literature has shown that people with depression have lower levels of peripheral brain-derived neurotrophic factor (BDNF), which may contribute to the pathophysiology of depression[37]. Physical activity increases the concentration of several neurotrophic factors, including BDNF, thus possibly having a protective effect on depression[38]. Participation in physical activity could give a positive mood to the participant and finally improve the ability to cope with depression[39]. Compared with the high grip strength group, people in the low and moderate strength grip group were older, more likely to develop chronic diseases. Handgrip strength was a good indicator of an individual's muscle mass, and lower handgrip strength represents poorer health status. Long-term physical inactivity may play a more important role in depression in a low state of health. Enough physical activity may not be effective in preventing depression among participants with health conditions. But in our present study, the sample size of people with physical inactivity was relatively small, which may induce an estimated confidence interval too wide resulting in a false negative conclusion.

A major strength of this study was a large number of participants from a prospective study, which gave our statistical analysis sufficient power to conclude. Besides, GBTM was used to identify grip strength groups by genders based on the studied population, which was more suitable than the percentage method. Third, we assessed the association of change in physical inactivity across the life span with depression. However, some limitations should be considered. First, self-reported evaluations of physical activity and other health-related status might lead to recall bias. Second, physical activity in SHARE did not differentiate between aerobic and strength training which may influence findings. Finally, despite controlling for many potential covariates, residual confounding may influence our observed associations between physical inactivity and grip strength on depression.

Conclusion

In summary, results from European middle-aged and older adults indicated that grip strength and physical inactivity play a joint effect on depression. Lower grip strength with physical inactivity could worsen depressive symptoms. Physical inactivity is associated with the change of depression in low and moderate grip strength but not in high grip strength. Attention should be paid to those with lower grip and physical inactivity to prevent depression.

Declarations

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Author contributions: Chongqi Jia provided the conception of research design and collated data at the early-stage preparations; Han Zheng did a brief preliminary analysis and completed remaining analyses and wrote the article. All authors reviewed the manuscript.

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Figures

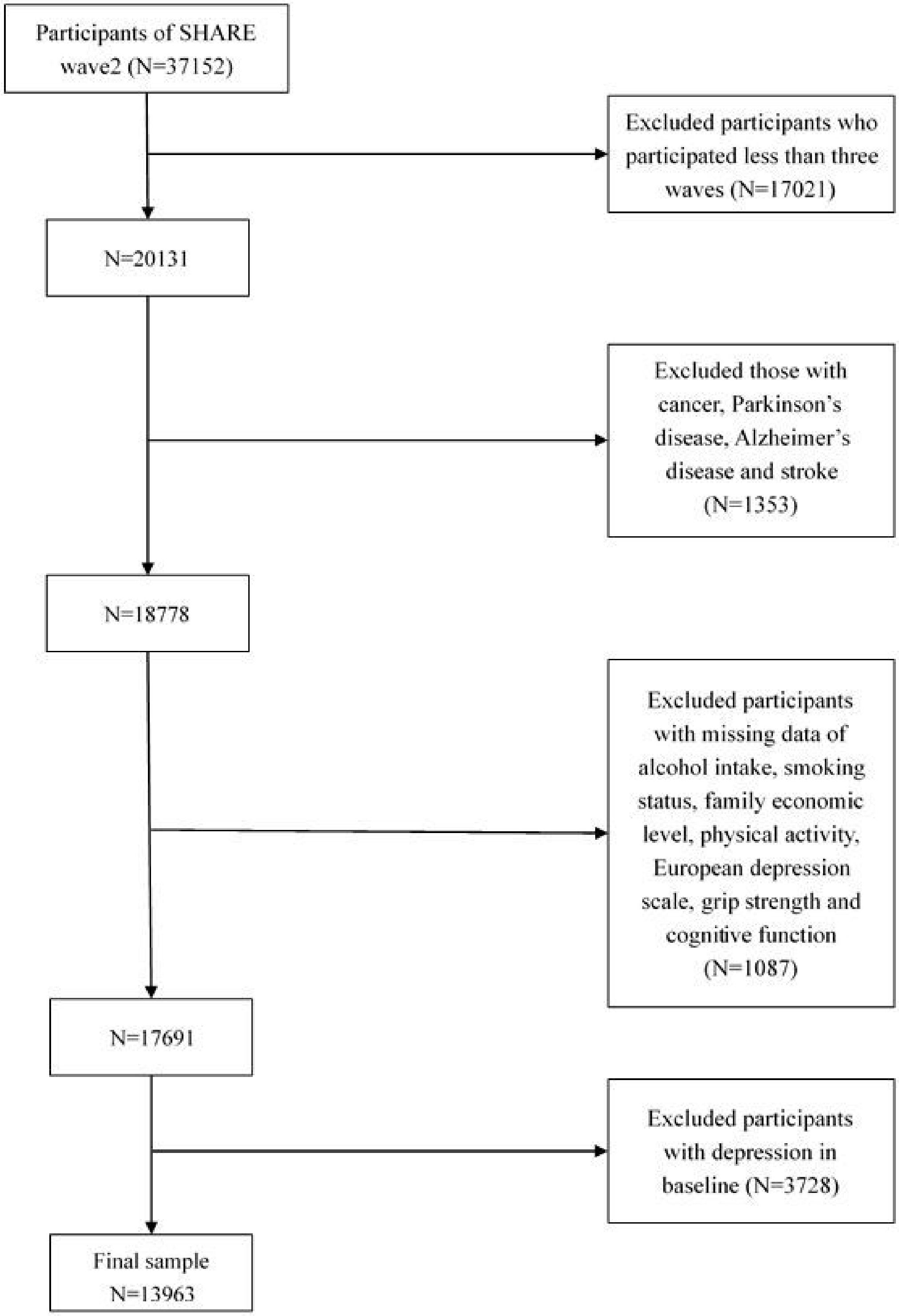

Figure 1

Flow chart of the analytic sample

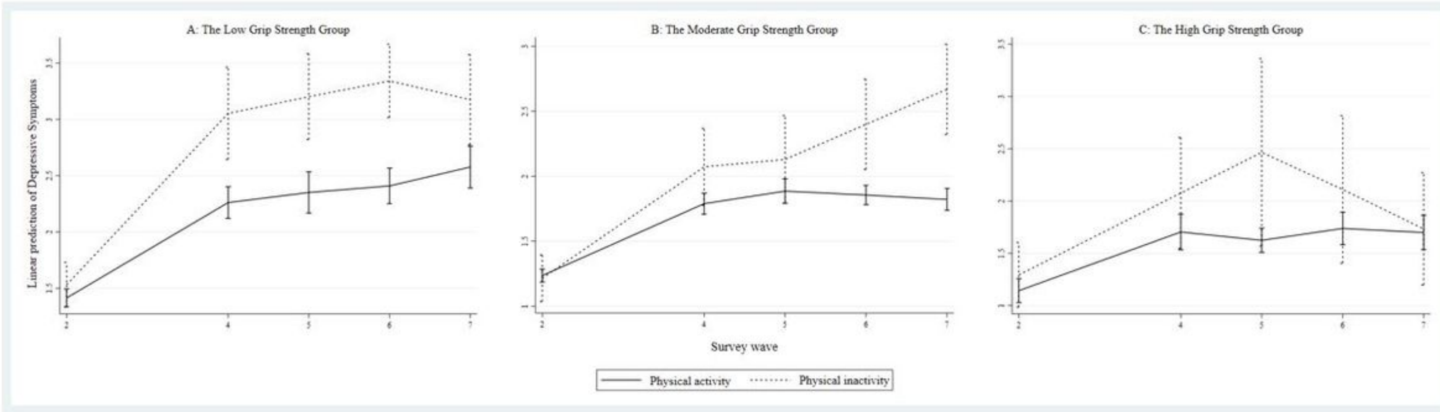

Figure 2

Physical inactivity on longitudinal change of depression score According to grip strength groups

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