Association between changes in handgrip strength and depression in Korean adults: a longitudinal panel study

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Depression in older adults is a global socioeconomic burden. Identifying factors, such as physical activity or exercise that can help prevent depression is important. We aimed to investigate the relationship between changes in handgrip strength and the presence of depression using longitudinal, nationwide data of older Korean adults. Data from the Korean Longitudinal Study of Aging were used in this study. A total of 6783 participants who had undergone a handgrip strength test and completed the short-form Center for Epidemiologic Studies Depression Scale (CESD-10-D) questionnaire from 2006 to 2018 were included. General estimating equations were used to assess the temporal effect of the changes in handgrip strength on depression. A decrease in handgrip strength was associated with high CESD-10-D scores (β = 0.1889 in men, β = 0.1552 in women). As a continuous variable, handgrip strength was negatively correlated with CESD-10-D scores (β = −0.0166 in men, β = −0.0196 in women). Changes in the handgrip strength were associated with depressive symptoms in our longitudinal study. Those who experienced a decrease in handgrip strength had severe depressive symptoms compared to those with unchanged or increased handgrip strength. These findings can be used to guide general health policies for the prevention of depression.

Globally, depression is a major health problem and a leading cause of socioeconomic burden due to its growing prevalence and associated high suicide rate1–5. In particular, South Korea has been struggling with a higher prevalence of suicidality than other countries of the Organization for Economic Co-operation and Development and thus has focused on mitigating the associated risks for the last few decades6,7. To address this problem, previous studies in South Korea have mainly focused on biological and psychological treatment methods for depression, such as medications and cognitive or behavioral psychotherapy8–10. However, it is important to find methods that involve lifestyle changes, such as eating habits, nutrition, exercise, and sleep pattern, to reduce the prevalence of depression. Among studies on the methods for modifying lifestyle, a previous study suggested that increased levels of exercise can help prevent depression11.

Patients with depression exhibit various symptoms, including reduced physical activity, with some patients showing an extreme form of inactivity because of catatonia. Researchers and clinicians have focused on the symptom-reducing function of physical activity or exercise among depressive patients. In fact, previous studies showed that exercise led to a reduction in depressive symptoms and that cognitive behavior therapy combined with exercise led to favorable outcomes12–17. These studies prompted many countries, including South Korea, to include exercise in their depression treatment guidelines16,17.

While the therapeutic potential of exercise in alleviating depression has been established, its efficacy as a depression prevention measure remains unclear. Previous studies found an association between initial physical activity and reduced depression18 and between handgrip strength asymmetry and depression19. However, very few studies have investigated the association between exercise and the prevalence of depression using a longitudinal study design. Moreover, previous studies did not use methods that allowed for instant measurement of the exercise status of the participants, thus limiting the utilization of the results in clinical settings. Therefore, this

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studies used handgrip strength, which can be measured instantly and easily, as a proxy for the muscle power status of a participant. Further, changes in handgrip strength can also be measured regularly to determine the exercise status of participants in a given period. This study aimed to investigate the relationship between changes in handgrip strength and depressive symptoms in a Korean adult population cohort selected from a panel study.

**Methods**

**Study population and data.** The data analyzed in this study were extracted from the Korean Longitudinal Study of Aging database (KLoSA). The KLoSA is a longitudinal panel survey of national representative samples of community-dwelling adults aged above 45 years and has been conducted every two years since 2006. The baseline data were gathered in 2006, where 10,254 Korean adults were interviewed by trained interviewers. The survey collected information on family background, demographics, family, health, employment status, income, and assets and included questionnaires on subjective expectations and subjective quality of life. In 2018, the seventh wave was conducted, and the effective sample number was 6,136 from the original panels and 804 from the newly included panels. In this study, we used biannual survey data from 2006 to 2018, resulting in seven rounds of data. After removing data with missing values for the study variables, 6,793 participants (3,052 men and 3,731 women) were included in this study. The baseline characteristics of the included and excluded individuals are shown in Table S1. For statistical analysis, each change in handgrip strength from 2006 to 2018, rather than each participant, was treated as an individual case.

**Measures.** The short-form Center for Epidemiologic Studies Depression Scale (CESD-10-D) was used for measuring depressive symptoms. The validity of the Korean version of CESD-10-D for screening depression is well established. The participants were asked to answer 10 questions about their depressive condition using a binomial scoring system. The KLoSA provides a raw score by adding the scores of all the answers, and this score ranges from 0 to 10, with high scores indicating high severity of depression. We used a CESD-10-D cut-off score of 3 to determine the association between the change in handgrip strength and the presence of depressive symptoms.

**Handgrip strength.** Handgrip strength was measured in kilograms using a handgrip dynamometer (Hand Grip Meter 6103, Tanita, Tokyo, Japan). The participants were asked to squeeze the dynamometer twice with each hand, and the highest value among the four trials was used in this study. The participants who refused to perform the test due to physical problems were excluded from the data analysis. To analyze the relationship between the change in handgrip strength and the presence of depressive symptoms, the changes in both domains over the previous year were recorded. The continuous variable of handgrip strength was categorized into two groups: (1) decreased and (2) same or increased; the analyses were conducted assuming the presence of continuous changes in the recorded values across the two groups.

**Covariates.** Demographic and health-related factors were included as covariates in the analysis. The following demographic characteristics were included: age, educational level, dwelling region, working status, household income, participation in social activities, and the number of cohabiting generations. The following health-related factors were included: smoking/alcohol use status, number of chronic medical conditions, body mass index (BMI), and perceived health status. All the covariates were measured using survey questionnaires. The KLoSA provides the number of chronic medical conditions for each participant, including hypertension, diabetes, cancers, chronic lung diseases, liver disease, cardiac disease, cerebrovascular diseases, psychiatric disease, arthritis, prostate disease, dementia, and other chronic diseases. All multivariable models were controlled for all of the covariates unless stated otherwise.

**Statistical analysis.** All statistical analyses were performed separately for men and women to rule out the effect of sex on depression. Analysis of variance was used to compare the general characteristics of the groups. A generalized estimating equation (GEE) model was used for regression analysis of CESD-10 scores, change in handgrip strength, and other covariates. CESD-10 score was included as the outcome variable, and other variables in Table 1 were included in the GEE model. We used normal distribution with the identity link function for continuous variables and binomial distribution and logit link function for binary outcome variables. The temporal variable was the wave, i.e., every 2 years, and person ID was used to identify repeated subjects using the unstructured working correlation matrix for the GEE model. The analysis was conducted twice: first, after dividing the change in handgrip strength into two groups; (1) decreased and (2) same or increased; the analyses were conducted assuming the presence of continuous changes in the recorded values across the two groups.

**Subgroup analyses were performed to assess the interaction between handgrip strength change and other variables that were associated with the CESD-10 score further. We conducted subgroup analyses for age, working status, participation in social activities, number of chronic medical conditions, and perceived health status. All analyses were carried out using SAS software version 9.4 (SAS Institute, Cary, North Carolina, USA), and the results were considered statistically significant if the p-value was <0.05 and very highly significant if the p-value was <0.001.

**Ethical considerations.** The KLoSA study was approved by Statistics Korea of the Korean Government (Approval number: 33602 and the Institutional Review Board of Korea National Institute for Ethics Policy (P01-201909-22-002). The survey was conducted after acquiring written informed consent of the participants by the trained study interviewer of KLoSA survey. This study was approved as exempt by the Institutional Review Board at the Dongsan University Health Science Institute (Approval number: 33602 and the Institutional Review Board of Korea National Institute for Ethics Policy (P01-201909-22-002).
|                          | Men (n = 3052) |     | Women (n = 3731) |     |
|--------------------------|----------------|-----|------------------|-----|
|                          | Participants   | CESD-10-D | p-value | Participants | CESD-10-D | p-value |
|                          | N   | %   | Mean | SD  |       | N   | %   | Mean | SD  |       |
| **Changes in handgrip strength** |     |     |     |     |       |     |     |     |     |       |
| Same or Increased        | 1213 | 39.7 | 3.042 | 2.756 |     | 1691 | 45.3 | 3.793 | 2.883 |     |
| Decreased                | 1839 | 60.3 | 3.058 | 2.698 |     | 2040 | 54.7 | 3.820 | 2.891 |     |
| **Age, years**           |     |     |     |     |       |     |     |     |     |       |
| 45–54                    | 845  | 27.7 | 2.512 | 2.445 |     | 1150 | 30.8 | 2.925 | 2.569 |     |
| 55–64                    | 954  | 31.3 | 2.698 | 2.585 |     | 1083 | 29.0 | 3.547 | 2.849 |     |
| 65–74                    | 890  | 29.2 | 3.430 | 2.826 |     | 1002 | 26.9 | 4.515 | 2.898 |     |
| ≥ 75                     | 363  | 11.9 | 4.309 | 2.884 |     | 496  | 13.3 | 4.994 | 2.897 |     |
| **Education level**      |     |     |     |     |       |     |     |     |     |       |
| Elementary school or less| 924  | 30.3 | 3.868 | 2.913 |     | 2018 | 54.1 | 4.466 | 2.930 |     |
| Middle school            | 529  | 17.3 | 3.149 | 2.805 |     | 642  | 17.2 | 3.402 | 2.735 |     |
| High school              | 1085 | 35.6 | 2.690 | 2.568 |     | 897  | 24.0 | 2.858 | 2.566 |     |
| University or beyond     | 514  | 16.8 | 2.247 | 2.146 |     | 174  | 4.7  | 2.557 | 2.427 |     |
| **Region**               |     |     |     |     |       |     |     |     |     |       |
| Metropolitan             | 1266 | 41.5 | 2.694 | 2.539 |     | 1589 | 42.6 | 3.497 | 2.821 |     |
| Small or medium cities   | 1009 | 33.1 | 3.105 | 2.804 |     | 1226 | 32.9 | 3.879 | 2.962 |     |
| Rural                    | 777  | 25.5 | 3.566 | 2.812 |     | 916  | 24.6 | 4.250 | 2.838 |     |
| **Working status**       |     |     |     |     |       |     |     |     |     |       |
| Working                  | 1937 | 63.5 | 2.590 | 2.519 |     | 1230 | 33.0 | 3.221 | 2.660 |     |
| Non-working              | 1115 | 36.5 | 3.854 | 2.870 |     | 2501 | 67.0 | 4.096 | 2.951 |     |
| **Household income**     |     |     |     |     |       |     |     |     |     |       |
| Quartile 1 (low)         | 609  | 20.0 | 4.118 | 2.866 |     | 988  | 26.5 | 4.968 | 2.947 |     |
| Quartile 2               | 825  | 27.0 | 3.238 | 2.775 |     | 997  | 26.7 | 3.876 | 2.839 |     |
| Quartile 3               | 865  | 28.3 | 2.690 | 2.576 |     | 910  | 24.4 | 3.313 | 2.737 |     |
| Quartile 4 (high)        | 753  | 24.7 | 2.401 | 2.409 |     | 836  | 22.4 | 2.894 | 2.549 |     |
| **Participation in social activities** |   |     |     |     |       |     |     |     |     |       |
| No                       | 538  | 17.6 | 4.126 | 3.002 |     | 819  | 22.0 | 4.722 | 2.988 |     |
| Yes                      | 2514 | 82.4 | 2.822 | 2.600 |     | 2912 | 78.0 | 3.550 | 2.805 |     |
| **Smoking**              |     |     |     |     |       |     |     |     |     |       |
| Current                  | 1188 | 38.9 | 3.115 | 2.748 |     | 109  | 2.9  | 5.459 | 3.114 |     |
| Former                   | 789  | 25.9 | 3.118 | 2.673 |     | 38   | 1.0  | 4.605 | 3.150 |     |
| Never                    | 1075 | 35.2 | 2.933 | 2.724 |     | 3584 | 96.1 | 3.749 | 2.862 |     |
| **Alcohol intake**       |     |     |     |     |       |     |     |     |     |       |
| Yes                      | 1926 | 63.1 | 2.911 | 2.659 |     | 715  | 19.2 | 3.418 | 2.774 |     |
| No                       | 1126 | 36.9 | 3.292 | 2.809 |     | 3016 | 80.8 | 3.900 | 2.906 |     |
| **Number of chronic medical conditions** |     |     |     |     |       |     |     |     |     |       |
| None                     | 175  | 51.6 | 2.639 | 2.558 |     | 1697 | 45.5 | 3.11  | 2.68  |     |
| 1                        | 905  | 29.7 | 3.190 | 2.737 |     | 1143 | 30.6 | 3.90  | 2.90  |     |
| ≥ 2                      | 572  | 18.7 | 3.970 | 2.884 |     | 891  | 23.9 | 5.00  | 2.86  |     |
| **Number of cohabiting generations** |     |     |     |     |       |     |     |     |     |       |
| Couple                   | 1424 | 46.7 | 3.270 | 2.786 |     | 1790 | 48.0 | 4.085 | 2.949 |     |
| Two generation           | 1287 | 42.2 | 3.210 | 2.602 |     | 1436 | 38.5 | 3.498 | 2.812 |     |
| Over two generation      | 341  | 11.2 | 3.053 | 2.814 |     | 505  | 13.5 | 3.705 | 2.782 |     |
| **BMI**                  |     |     |     |     |       |     |     |     |     |       |
| Underweight              | 92   | 3.0  | 4.000 | 3.045 |     | 113  | 3.0  | 4.301 | 3.062 |     |
| Normal weight            | 1341 | 43.9 | 3.293 | 2.787 |     | 1647 | 44.1 | 3.760 | 2.878 |     |
| Overweight               | 1027 | 33.7 | 3.888 | 2.627 |     | 1039 | 27.8 | 3.774 | 2.831 |     |
| Obesity                  | 559  | 18.3 | 2.615 | 2.579 |     | 820  | 22.0 | 3.883 | 2.913 |     |
| Severe obesity           | 33   | 1.1  | 3.091 | 2.788 |     | 112  | 3.0  | 3.768 | 3.148 |     |
| **Perceived health status** |     |     |     |     |       |     |     |     |     |       |
| Continued                |     |     |     |     |       |     |     |     |     |       |
which were highly significant at p < 0.0001. A decrease in handgrip strength was associated with an increase in CESD-10-D scores in both sexes. However, the other covariates such as age, educational level, region, working status, household income, participation in social activities, number of chronic medical conditions, BMI, and perceived health status significantly differed in CESD-10-D scores for both sexes.

Table 2 shows the multiple regression analysis results for the CESD-10-D score and groups of change in handgrip after adjusting for the covariates. Compared to the same or increased handgrip strength group, the decreased handgrip strength group showed regression coefficients of 0.1889 in men and 0.1552 in women, with a high significance level of p < 0.0001. A decrease in handgrip strength was associated with an increase in CESD-10-D scores in both sexes. The results of the other covariates are shown in Table 2. The regression coefficients were −0.0166 in men and −0.0196 in women, with a high significance level of p < 0.0001. These results suggest that the change in handgrip strength was negatively associated with the CESD-10-D total score in both sexes. Table 3 shows that the decreased handgrip strength group showed a higher odds ratio (OR) for depression (OR = 1.18, 95% confidence interval [CI] 1.10–1.27 in men, OR = 1.09, 95% CI 1.02–1.16 in women) after dividing the participants into two groups using the CESD-10-D cut-off score of 3.

The results of the subgroup analysis are shown in Table S2. When we grouped the data by age, all age groups showed high CESD-10 scores when their handgrip strength had decreased, except the oldest male and female groups, which showed no significant relationship between handgrip change and depression.

Discussions

We found that a decrease in handgrip strength during the previous 2 years was associated with depressive symptoms in Korean adults. The participants whose handgrip strength decreased had reported higher CESD-10-D scores than those whose handgrip strength had remained the same or increased in the same period. Furthermore, we found that handgrip strength was negatively correlated with the CESD-10-D score in our study population.

The results of the present study are generally consistent with those of previous studies, namely that handgrip strength was associated with a high prevalence of depression or an increase in depressive symptoms. For example, one study found that weak handgrip strength was associated with a high odds ratio for depression in low- and middle-income countries. Although it was a cross-sectional study, the odds ratio of depression was 1.45 in men and 1.55 in women, which were highly significant at p < 0.0001. A decrease in handgrip strength was associated with an increase in CESD-10-D scores in both sexes. The results of the other covariates are shown in Table 2. The regression coefficients were −0.0166 in men and −0.0196 in women, with a high significance level of p < 0.0001. These results suggest that the change in handgrip strength was negatively associated with the CESD-10-D total score in both sexes. Table 4 shows that the decreased handgrip strength group showed a higher odds ratio (OR) for depression (OR = 1.18, 95% confidence interval [CI] 1.10–1.27 in men, OR = 1.09, 95% CI 1.02–1.16 in women) after dividing the participants into two groups using the CESD-10-D cut-off score of 3.

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Table 2. Results of the generalized estimating equation analysis of handgrip strength change in the two groups and short-form Center for Epidemiologic Studies Depression Scale scores. Underweight: BMI < 18.5; normal weight: 18.5 ≤ BMI < 23; overweight: 23 ≤ BMI < 25; obesity: 25 ≤ BMI < 30; severe obesity: 30 ≤ BMI. BMI body mass index, S.E. standard error.
of tryptophan in the serum and cerebrospinal fluid lead to increased levels of serotonin and dopamine, resulting in a reduction in depression\textsuperscript{35,36}. Exercise has also been found to increase the levels of brain-derived neurotrophic factor (BDNF), which is known to regenerate as well as enhance the function of the hippocampus. Given that decreased levels of BDNF have been found to be related to depression in older patients, exercise may not only reverse but also prevent depressive symptoms by increasing BDNF levels\textsuperscript{37}. These previous studies suggest that exercise might prevent depression, and since we can measure the exercise status via handgrip strength, it might be associated with depression in individuals.

This study had some limitations. First, we used survey-based data and excluded non-responders; thus, the results might have been affected by this bias. Individuals with severe depression or severe sarcopenia might not have accurately responded to the survey or may not have been included; thus, our results might have been underestimated. Second, we could not determine the biological risk factors for depression since we used only a survey-based database. As several biological factors have been established as risk factors for depression in adults, future studies should analyze them in regression models\textsuperscript{38}. Third, causation could not be determined because of the lack of a prospective design. We used the change in handgrip strength between two waves and analyzed its association with depressive symptoms in the subsequent wave to minimize the risk of reciprocal causation. However, depressive symptoms in the previous waves could have caused a decrease in handgrip strength. Thus, future studies using a prospective design including interventions of strengthening exercises are needed to establish the causal relationship between changes in handgrip strength and depressive symptomology.

Despite these limitations, our study has many strengths. We conducted the analysis with a relatively large sample size that represented the general adult population of South Korea and used a longitudinal design. These results can be applied to the general Korean population to establish health care policies or conduct future studies. We used standardized tools to measure muscle strength. Handgrip strength is easily measurable and can be standardized across different groups and studies. Third, we used the change in handgrip strength rather than baseline strength; thus, the results could be analyzed as the exercise or physical activity status of the previous period. Finally, our results suggest that increasing handgrip strength by modifying lifestyle habits is a useful strategy for preventing depressive symptoms in adults.

In conclusion, this longitudinal, large-sized study showed that change in handgrip strength was associated with depressive symptoms in South Korea. A decrease in handgrip strength was associated with severe depressive symptoms compared to no change or increased handgrip strength. Future studies exploring the underlying mechanisms of this association as well as the preventive effects of increasing handgrip strength on depressive symptoms may provide valuable strategies for treating and preventing depressive symptoms.

Data availability
The datasets analyzed during the current study are available in the KLoSA repository, \url{https://survey.keis.or.kr/eng/klosa/databoard/List.jsp}.

Received: 25 April 2022; Accepted: 4 August 2022
Published online: 11 August 2022

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### Table 3.

|          | Men  |          |          | Women |          |          |
|----------|------|----------|----------|-------|----------|----------|
|          | β   | S.E.     | p-value  | β    | S.E.     | p-value  |
| Handgrip strength change (kg) | − 0.0166 | 0.0030 | < 0.0001 | − 0.0196 | 0.0039 | < 0.0001 |

### Table 4.

|                          | Men          |          |          | Women       |          |          |
|--------------------------|--------------|----------|----------|-------------|----------|----------|
|                          | Adjusted OR  | 95% CI   | Adjusted OR | 95% CI     |          |          |
| Changes in Handgrip strength |              |          |            |             |          |          |
| Same or increased        | Ref          |          | Ref       |             |          |          |
| Decreased                | 1.18 (1.10–1.27) |          | 1.09 (1.02–1.16) |          |          |
wide survey.

We would like to thank the Korea Employment Information Service, which provided the data based on a nation-

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Acknowledgements

We would like to thank the Korea Employment Information Service, which provided the data based on a nation-

wide survey.
Author contributions
H.K. and W.J. had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. Concept and design: H.K., S.I.J.; data acquisition, analysis, and interpretation of data: H.K., Y.S.P.; drafting of the manuscript: H.K., S.H.K.; critical revision of the manuscript for important intellectual content: Y.K., E.C.P., S.I.J.; statistical analysis: H.K., S.H.K.; supervision: E.C.P.

Competing interests
The authors declare no competing interests.

Additional information
Supplementary Information The online version contains supplementary material available at https://doi.org/10.1038/s41598-022-18089-9.

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