Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Journal of Psychosomatic Research 166 (2023) 111160

Contents lists available at ScienceDirect

Journal of Psychosomatic Research

journal homepage: www.elsevier.com/locate/jpsychores

Is COVID-19 induced reductions in the level of physical activity associated with increased depressive symptoms in patients with hypertension?

Yeong Jun Ju [a,1], Woorim Kim [b,1], Soon Young Lee [a,*]

[a] Department of Preventive Medicine and Public Health, Ajou University School of Medicine, Suwon-si, Gyeonggi-do, Republic of Korea
[b] Division of Cancer Control & Policy, National Cancer Control Institute, National Cancer Center, Goyang-si, Gyeonggi-do, Republic of Korea

ARTICLE INFO

Keywords:
COVID-19
Depression
Physical activity
Hypertension

ABSTRACT

Background: Studies have reported that the coronavirus 2019 (COVID-19) outbreak led to reduced levels of physical activity, but this has been rarely studied in patients with hypertension. This study investigated the association between depressive symptoms and changes in physical activity of patients with hypertension during the COVID-19 outbreak.

Methods: Data were from the Korea Community Health Survey (KCHS), conducted between August to November 2020. The KCHS is a nationwide cross-sectional survey that evaluates information on various sociodemographic, economic, and health related variables. Depressive symptoms were measured using the Patient Health Questionnaire-9. Physical activity was measured using a questionnaire inquiring whether participants experienced any changes in physical activity after the pandemic. The association between depressive symptoms and changes in physical activity level were analyzed using a multivariable logistic regression analysis.

Results: Out of 55,203 patients, 39.6% responded that they had experienced lower levels of physical activity due to the pandemic and showed increased likelihoods of depressive symptoms (OR 1.33, 95% CI 1.14–1.54) than individuals who responded that they had performed similar levels of physical activity. This tendency was stronger in patients that did not receive treatment for hypertension (OR 2.07, 95% CI 1.02–4.23) than those who did receive treatment with marginal significance (*p*-value of interaction term: 0.1241).

Conclusions: Decreased levels of physical activity due to the outbreak was experienced by a noticeable proportion of patients with hypertension and was associated with increased likelihoods of depressive symptoms.

1. Introduction

Since the first coronavirus 2019 (COVID-19) case reported in December 2019, the disease remains an important public health issue worldwide [1]. In order to contain the rapid dissemination of the disease, which may inevitably impact the mental and physical health of numerous individuals, many countries adopted stay-at-home restrictions and case isolation strategies [2]. It has been suggested that the possible side effects of the pandemic include psychiatric disorders such as depression, which is particularly crucial in South Korea which has a high rate of suicide deaths [3,4]. In fact, previous reports have revealed that the COVID-19 outbreak and the imposition of various measures to restrict the spread of the virus were associated with poorer mental health and increased suicide deaths [5].

Physical activity, defined as the bodily movements of the skeletal muscles resulting in the expenditure of energy, is an important protective factor against depression [6,7]. Specifically, structured physical activity or exercise, is known to have beneficial effects for health improvement and has been cited as a modifiable risk factor for many diseases, including depression [8,9]. However, due to the implementation of physical distancing and isolation strategies during the outbreak, many countries reported reduced levels of physical activity in the general population [10]. This tendency is hardly surprising since it is comparatively difficult to perform high levels of physical activity in periods of confinement [11]. Such findings have presented a health concern as physical activity is known to provide immediate and long-term psychological benefits [12]. Low physical activity has also been related to loneliness and feelings of low social support [13,14].

* Corresponding author at: Department of Preventive Medicine and Public Health, Ajou University School of Medicine, 206 World cup-ro, Yeongtong-gu, Suwon-si, Gyeonggi-do 16499, Republic of Korea.
E-mail address: solee@ajou.ac.kr (S.Y. Lee).
[1] Denotes equal contribution

https://doi.org/10.1016/j.jpsychores.2023.111160
Received 28 September 2021; Received in revised form 11 January 2023; Accepted 17 January 2023
Available online 20 January 2023

Considering the potential impact of decreased physical activity due to the COVID-19 outbreak on the psychological health of individuals, this hindrance may act as a particular challenge for patients with hypertension because in addition to pharmacological treatment, non-pharmacological treatment involving lifestyle factors is commonly used to effectively manage blood pressure [15]. Management of high blood pressure is stressed because it is a strong risk factor for cardiovascular diseases [16]. As such, physical activity may play a comparatively important role in managing the health of patients with hypertension and as psychiatric diseases often co-exist with hypertension, physical activity may benefit the symptoms of both these problems [17]. Hence, lower levels of exercise due to the pandemic may be particularly associated with depression in patients with hypertension [18]. This leads to the hypothesis that decreased physical activity experienced during the COVID-19 outbreak may be associated with a higher likelihood of depressive symptoms in patients with hypertension. This study investigated whether reduced levels of physical activity caused by the COVID-19 outbreak was associated with higher likelihoods of depressive symptoms in patients with hypertension. Different moderators, including gender, socioeconomic status, and current treatment status for hypertension were tested in the subgroup analysis. A particular focus was put on current treatment status because the impact of physical activity may differ according to disease severity.

2. Methods

2.1. Data and study population

For this study, we used raw data from the 2020 Korean Community Health Survey (KCHS), conducted by the Korea Disease Control and Prevention Agency (KDCA). This survey was conducted during the pandemic (August 2020 to November 2020). The KCHS is a cross-sectional survey that collects reliable health-related data. The survey is conducted annually, and it collects information through in-person interviews. Since the population sample is extracted from the national survey data, the samples are representative of the Korean population [19].

The study only included individuals diagnosed with hypertension by a physician. From an initial total of 64,022 patients with hypertension, those with missing data in relevant variables were excluded, and the remaining 55,203 participants were included in the present study (see details in Fig. 1).

2.2. Dependent variable

The dependent variable was depressive symptoms, which were measured based on the Korean version of the Patient Health Questionnaire-9 (PHQ-9). The PHQ-9, a tool used to screen for depression, measured the frequency of the relevant symptoms experienced in the past two weeks [20]. This tool is inquired to the KCHS participants by trained interviewers using the computer assisted personal interview (CAPI) method and recorded accordingly. Scores on the PHQ-9 ranges from 0 to 27. The validity and reliability of the Korean PHQ-9 has been previously verified [21]. In accordance with preceding studies [22], a cut-off score of 10 was applied to indicate depressive symptoms and higher scores indicated more severe symptoms.

2.3. Independent variables

The independent variable was the level of changes in physical activity during the outbreak compared to before. This was measured based on a question measured in the KCHS, "Compared to before the COVID-19 outbreak, did you experience any changes in the level of physical activity (both indoor and outdoor)?" The data was collected during the pandemic (from August 2020 to November 2020) based on the CAPI method administered by trained interviewers. The available responses were i) more than before, ii) similar to before, and iii) lesser than before.

This study also incorporated various sociodemographic, economic, and health related covariates. These were sex, age, education level, income, job classification, area of residence, monthly drinking status, smoking status, moderate to vigorous physical exercise, perceived stress level, subjective health status, hypertension treatment status, unmet

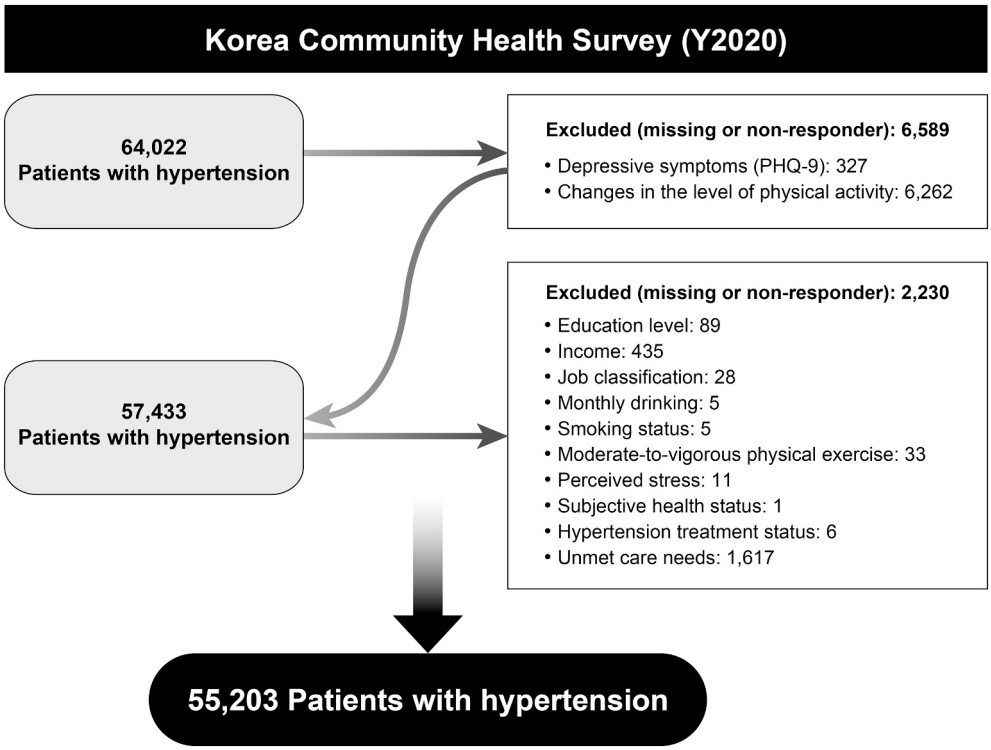

Fig. 1. Flow-chart of study participants selection process.

care needs, and the level of changes in daily activities experienced due to COVID-19. Current hypertension treatment status was categorized into two groups, no treatment and received treatment. In the KCHS data, individuals were inquired whether they were diagnosed with hypertension by a physician. Individuals who replied to have been diagnosed were further asked whether they were currently receiving non-pharmacological or pharmacological treatment for hypertension. The treatment group included those who were currently receiving pharmacological treatment or non-pharmacological treatment to control their blood pressure. The moderate-to-vigorous physical activity (MVPA) was measured using the International Physical Activity Questionnaire (IPAQ) [23]. The IPAQ was also inquired and measured using the CAPI method in the KCHS. Regarding MVPA, responses were divided into 2 categories ("yes" or "no"), with the "yes" group consisting of individuals

Table 1
General characteristics of the study participants.

Variables	Total		Depressive symptoms				*P*-Value
			No (PHQ-9 < 10)		Yes (PHQ-9 ≥ 10)		
	N	%	N	%	N	%	
Level of physical activity							<0.001
Higher than before COVID-19	2850	5.2	2781	97.6	69	2.4	
Similar to before COVID-19	30,478	55.2	29,686	97.4	792	2.6	
Lower than before COVID-19	21,875	39.6	20,971	95.9	904	4.1	
Sex							<0.001
Male	24,948	45.2	24,394	97.8	554	2.2	
Female	30,255	54.8	29,044	96.0	1211	4.0	
Age							<0.001
19–29	249	0.5	227	91.2	22	8.8	
30–39	820	1.5	777	94.8	43	5.2	
40–49	3469	6.3	3373	97.2	96	2.8	
50–59	9445	17.1	9208	97.5	237	2.5	
60–69	16,152	29.3	15,736	97.4	416	2.6	
70+	25,068	45.4	24,117	96.2	951	3.8	
Education level							<0.001
None	9645	17.5	9124	94.6	521	5.4	
Elementary school	14,167	25.7	13,686	96.6	481	3.4	
Middle school	8929	16.2	8670	97.1	259	2.9	
High school	14,117	25.6	13,770	97.5	347	2.5	
College or above	8345	15.1	8188	98.1	157	1.9	
Income							<0.001
Low	15,023	27.2	14,195	94.5	828	5.5	
Low-middle	21,053	38.1	20,460	97.2	593	2.8	
Middle-High	10,213	18.5	10,002	97.9	211	2.1	
High	8914	16.2	8781	98.5	133	1.5	
Job classification							<0.001
Professional or administrative position	2760	5.0	2714	98.3	46	1.7	
Office work	2008	3.6	1986	98.9	22	1.1	
Sales and service	5048	9.1	4955	98.2	93	1.8	
Agriculture and fishery	7334	13.3	7234	98.6	100	1.4	
Blue collar work or simple labor	10,918	19.8	10,715	98.1	203	1.9	
Unemployed	27,135	49.2	25,834	95.2	1301	4.8	
Area of residence							<0.001
Urban	26,274	47.6	25,346	96.5	928	3.5	
Rural	28,929	52.4	28,092	97.1	837	2.9	
Monthly drinking status							<0.001
No	35,826	64.9	34,507	96.3	1319	3.7	
Yes	19,377	35.1	18,931	97.7	446	2.3	
Smoking status							0.0288
No	48,288	87.5	46,774	96.9	1514	3.1	
Yes	6915	12.5	6664	96.4	251	3.6	
Moderate-to-vigorous physical exercise							<0.001
No	48,977	88.7	47,326	96.6	1651	3.4	
Yes	6226	11.3	6112	98.2	114	1.8	
Perceived stress level							<0.001
No	44,933	81.4	44,291	98.6	642	1.4	
Yes	10,270	18.6	9147	89.1	1123	10.9	
Subjective health status							<0.001
Poor	37,506	67.9	35,870	95.6	1636	4.4	
Fair	17,697	32.1	17,568	99.3	129	0.7	
Hypertension treatment status							<0.001
No treatment	1479	2.7	1391	94.1	88	6.0	
Yes treatment	53,724	97.3	52,047	96.9	1677	3.1	
Unmet care needs							<0.001
No	52,569	95.2	51,090	97.2	1479	2.8	
Yes	2634	4.8	2348	89.1	286	10.9	
Changes in daily activities due to COVID-19							<0.001
High level of disruption	14,273	25.9	13,641	95.6	632	4.4	
Mediocre level of disruption	14,356	26.0	13,944	97.1	412	2.9	
Low level of disruption	13,184	23.9	12,889	97.8	295	2.2	
No disruption	13,390	24.3	12,964	96.8	426	3.2	
Total	55,203	100.0	53,438	96.8	1765	3.2	

who exercise moderately more than two hours and thirty minutes per week or intensively more than one hour and fifteen minutes per week. One minute of intensive physical activity was defined as equivalent to two minutes of moderate physical activity.

2.4. Ethical approval

The Korea Community Health Survey (KCHS) data are openly published. Participants' data were fully anonymized prior to release. Our study was excluded from the review list pursuant to Article 2.2 of the Enforcement Rule of Bioethics and Safety Act in Korea, since the data was exempted from IRB review.

2.5. Statistical analysis

A chi-square test was conducted to analyze the general characteristics of the study participants. The association between depressive symptoms and changes in physical activity level compared to before the COVID-19 outbreak were examined using a multivariable logistic regression analysis. The analysis was conducted after adjusting for all covariates. The subgroup analysis was performed based on the current hypertension treatment status. All results were expressed as Odds Ratio (OR) and their 95% Confidence Interval (95% CI). *P*-values were two-sided and considered significant at $p < 0.05$. All analyses were conducted using the SAS 9.4 (SAS Institute, Cary, NC, USA) software.

3. Results

Table 1 presents the general characteristics of the study participants. A total of 55,203 individuals with hypertension were included, of which 1765 (3.2%) had depressive symptoms. Compared to before the COVID-19 outbreak, 2850 (5.2%) participants responded they had higher levels physical activity, 30,478 (55.2%) had similar levels, and 21,875 (39.6%) had lower levels during the pandemic. The proportion of individuals with depressive symptoms were noticeably higher in the group of individuals who experienced decreased physical activity (4.1%) due to the pandemic (similar level of physical activity was 2.6%; higher level of physical activity was 2.4%). Depressive symptoms were also more commonly found in participants who did not meet the recommended MVPA level (3.4%) than those who did (1.8%).

Table 2 shows the results of the multivariable logistic regression analysis on the association between depressive symptoms and changes in physical activity due to the COVID-19 outbreak. Compared to individuals who performed similar levels of physical activity during the pandemic, participants who had lower levels (OR 1.33, 95% CI 1.14–1.54) had increased likelihoods of depressive symptoms. Additionally, individuals who received treatment for hypertension (OR 0.56, 95% CI 0.39–0.78) showed lower odds for experiencing depressive symptoms. Participants who met the recommended MVPA level also tended to have a lower likelihood of depressive symptoms (OR 0.85, 95% CI 0.62–1.17).

Fig. 2 reveals the results of the subgroup analysis. The general tendencies of the main findings were maintained regardless of hypertension treatment status. The degree of the association found between depressive symptoms and changes in level of physical activity due to the COVID-19 outbreak was stronger in patients that did not receive treatment (lower levels of physical activity: OR 2.07, 95% CI 1.02–4.23) than those who did receive treatment (lower levels of physical activity: OR 1.31, 95% CI 1.13–1.52) with marginal significance (*p*-value of interaction term: 0.1241). The results of other moderators, namely gender, income, and occupation, can be found in Supplementary Tables 1–1, 1–2, and 1–3.

4. Discussion

The findings of this study revealed that alterations in level of physical

Table 2
The association between depressive symptoms and changes in the level of physical activity due to the COVID-19.

Variables	Depressive symptoms (PHQ-9 ≥ 10)			
	Adjusted-OR*	95% confidence interval		
Level of physical activity				
Higher than before COVID-19	1.05	0.73	–	1.50
Similar to before COVID-19	1.00			
Lower than before COVID-19	1.33	1.14	–	1.54
Sex				
Male	1.00			
Female	1.31	1.09	–	1.58
Age				
19–29	1.00			
30–39	0.84	0.42	–	1.67
40–49	0.41	0.22	–	0.76
50–59	0.41	0.23	–	0.74
60–69	0.34	0.19	–	0.61
70+	0.33	0.18	–	0.60
Education level				
None	1.00			
Elementary school	0.78	0.63	–	0.96
Middle school	0.71	0.56	–	0.90
High school	0.61	0.47	–	0.79
College or above	0.51	0.36	–	0.71
Income				
Low	1.00			
Low-middle	0.55	0.46	–	0.66
Middle-high	0.46	0.35	–	0.59
High	0.31	0.23	–	0.42
Job classification				
Professional or administrative position	1.00			
Office work	0.77	0.41	–	1.45
Sales and service	1.17	0.72	–	1.91
Agriculture and fishery	0.68	0.42	–	1.12
Blue collar work or simple labor	0.96	0.61	–	1.51
Unemployed	2.27	1.47	–	3.51
Area of residence				
Urban	1.00			
Rural	0.94	0.80	–	1.10
Monthly drinking status				
No	1.00			
Yes	0.98	0.82	–	1.18
Smoking status				
No	1.00			
Yes	1.32	1.06	–	1.66
Moderate-to-vigorous physical exercise				
No	1.00			
Yes	0.85	0.62	–	1.17
Perceived stress level				
No	1.00			
Yes	7.08	6.14	–	8.15
Subjective health status				
Poor	1.00			
Fair	0.28	0.22	–	0.36
Hypertension treatment status				
No treatment	1.00			
Yes treatment	0.56	0.39	–	0.78
Unmet care needs				
No	1.00			
Yes	2.63	2.12	–	3.26
Changes in daily activities due to COVID-19				
High level of disruption	1.00			
Mediocre level of disruption	0.77	0.64	–	0.92
Low level of disruption	0.72	0.59	–	0.88
No disruption	0.94	0.77	–	1.15

* The adjusted odds ratios were calculated using multivariable logistic regression analysis and adjusted for sex, age, education level, income, job classification, area of residence, monthly drinking, smoking status, moderate-to-vigorous physical exercise, perceived stress level, subjective health status, hypertension treatment status, unmet care needs, and changes in daily activities due to COVID-19.

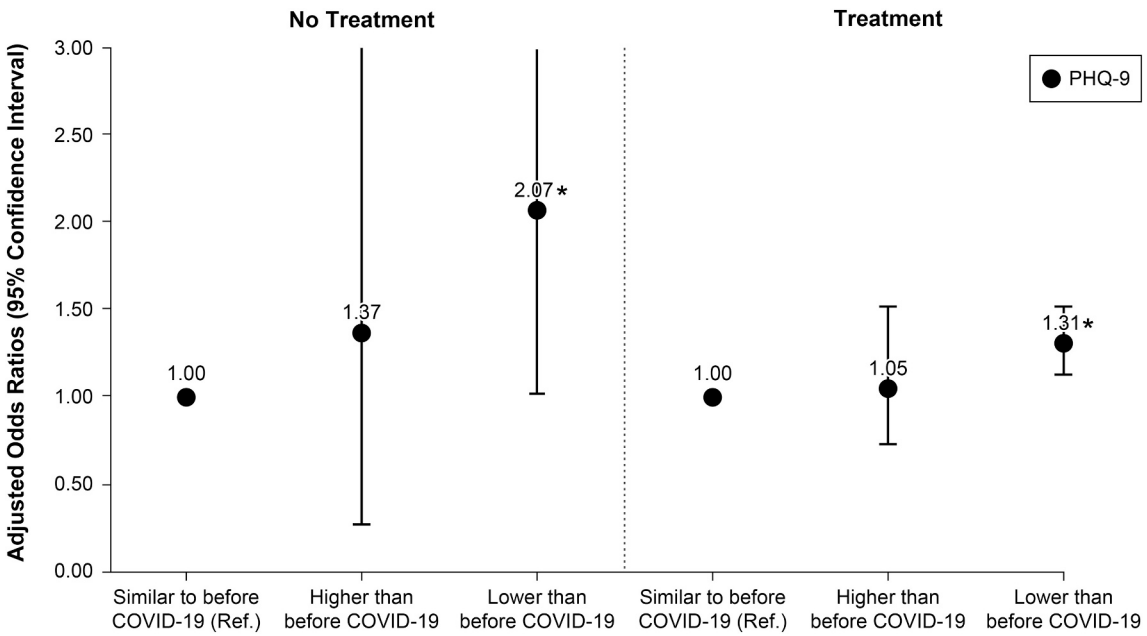

Fig. 2. The results of subgroup analysis of the association between depressive symptoms and changes in physical activity due to COVID-19 outbreak by hypertension treatment status. The adjusted odds ratios were calculated using multivariable logistic regression analysis and adjusted for sex, age, education level, income, job classification, area of residence, monthly drinking, smoking status, moderate-to-vigorous physical exercise, perceived stress level, subjective health status, unmet care needs, and changes in daily activities due to COVID-19. Statistically significant values are denoted with an asterisk.

activity, during the COVID-19 outbreak compared to the pre-pandemic period, was experienced by a significant proportion of patients with hypertension. A higher percentage of patients who reported lower levels of physical activity during the outbreak had PHQ-9 scores of 10 or higher, which indicated depressive symptoms. These individuals were also more likely to express depressive symptoms than those who experienced no change in their level of activities compared to the pre-pandemic period. Furthermore, such escalations were particularly pronounced in patients who had not received treatment for hypertension.

Studies have demonstrated the potential benefits of physical activity on prevention of depressive symptoms, and even minor amounts of activity such as walking <150 min per week showed a lower incidence rate of depressive episodes [24]. The pandemic has impaired the opportunities to be active due to the closing of common sporting facilities and promotion of home confinement which has led to reductions in physical activity [10]. A general lack of sporting activities, which was correlated with lower levels of physical activity, was also reported by many individuals [25]. Hence, although habitually active individuals may be able to maintain or even increase their physical activity levels, those who did not exercise daily may not have experienced a decrease [26]. Such inevitable disruptions may result in various negative effects that can elevate the risk of depressive symptoms, such as physical discomfort, feelings of less control in everyday activities, poorer mood, and lower body satisfaction [27]. Although the mechanism for explaining the correlation between depressive symptoms and physical activity are diverse and require further understanding, both biochemical mechanisms and psychosocial factors have been known to interfere with this correlation [7]. These tendencies need to be addressed as many individuals reported increased levels of negative mental health outcomes than before the COVID-19 outbreak [28].

The results of the analysis are particularly important because they demonstrate a relationship between depressive symptoms and reductions in physical activity in patients with hypertension due to the pandemic. Previous findings have reported that physical activity reduced the development of depressive moods, and such decreases were more pronounced in patients with chronic diseases [29]. Chronic diseases, including hypertension, are demonstrated to enhance the risk of depression. Simultaneously, a lack of physical activity can also increase depressive symptoms, which may lead to increased functional impairment and loss of productivity loss, that is known to adversely impact the course of chronic diseases [30]. Many studies have cited physical activity as an important modifiable risk factor in the prevention of the development of hypertension and have consistently demonstrated that exercise was beneficial in the reduction of blood pressure in individuals with hypertension [31]. Hence, while facing uncontrollable environmental changes, opportunities for physical activity may have been particularly significant in patients with hypertension. This is because, in addition to physical activity itself, increase in the odds of depressive symptoms and decrease in physical activity can influence disease outcomes and lead to a poorer mood [29].

Previous literature has reported different moderators, including gender and socioeconomic status [32]. As such, this study explored gender, income, occupation, and treatment status of hypertension in the analyses. The results revealed that the association between depressive symptoms and changes in physical activity due to the COVID-19 did not vary distinctively according to gender or occupation. Although some differences were found regarding income, the interaction tests were not significant for all three variables. However, in the case of current treatment status for hypertension, the analyses showed that the degree of the relationship between depressive symptoms and reductions in physical activity was stronger in patients with hypertension who did not receive treatment, with the results showing marginal significance. This is noteworthy as it suggests that restraints in physical activity experienced during the pandemic may have been stronger in patients with lower severity as they are more likely to use a lifestyle only approach in managing blood pressure [33]. Moreover, considering that the global treatment rate of hypertension is approximately 47% in women and 38% in men, attention should be given to the correlation found between changes in physical activity and depressive symptoms during the pandemic in this study [34]. The findings together infer the importance of maintaining physical activities in patients with hypertension to prevent depressive symptoms during the pandemic, particularly if the patients are currently not receiving treatment.

This study has some limitations. First, since this study was cross-

sectional, causal inferences should be made with caution. The possibility of reverse causality, in which depression may perhaps precede or contribute slightly to lower physical activity, cannot be completely ignored. Second, information on the practice of physical activity was measured based on self-reports in the KCHS, which means that the possibility of the self-reporting bias cannot be completely ruled out. Third, the KCHS data only inquired whether respondents experienced a general decrease in physical activity due to the COVID-19 outbreak. Hence, specific information on the frequency and intensity of physical activity could not be assessed due to data limitations. Fourth, the severity of hypertension (duration, blood pressure level, etc.) could not be accounted for in the analysis due to data limitations. However, this study did consider whether hypertension diagnosed individuals received further treatment. Last, although the validity and reliability of the PHQ-9 has been verified, the measurements may not necessarily infer a clinical diagnosis of depression. However, despite the abovementioned limitations, this study offers some important insights as it uses data from a nationally, representative sample and reveals that a noticeable percentage of patients with hypertension experienced a decrease in physical activity during the COVID-19 outbreak. Additionally, such reductions were associated with increased likelihoods of depressive symptoms. Moreover, the findings also reveal that this correlation may be stronger in patients who had not received any treatment for hypertension, and suggests the potential need to monitor and manage this particularly vulnerable group of individuals.

In conclusion, due to the COVID-19 outbreak, a noticeable proportion of the patients with hypertension experienced decreased levels of physical activity. This reduction in physical activity was associated with the increased likelihoods of depressive symptoms. Additionally, the magnitude of the relationship between depressive symptoms and alterations in physical activity compared to the pre-pandemic period was pronounced in patients who were currently not receiving any type of treatment. Considering that the pandemic can present significant risks to the mental health of individuals, our findings suggest the potential importance of promoting the integration of physical activity into daily life routines of patients with hypertension.

Funding

This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (Ministry of Science and ICT) (No. NRF-2022R1C1C2003977) and the National Cancer Center of Korea (Grant number NCC-2210802-1). The funding source was not involved in the study design, data analysis and interpretation, writing of the manuscript or in the decision to submit the manuscript for publication.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request. The dataset is available on the Korea Community Health Survey website (https://chs.kdca.go.kr/chs/rdr/rdrInfoProcessMain.do).

Acknowledgements

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jpsychores.2023.111160.

References

[1] C. Binns, W.Y. Low, L.M. Kyung, The COVID-19 pandemic: public health and epidemiology, Asia Pac. J. Public Health 32 (4) (2020) 140–144.
[2] J. Torales, M. O'Higgins, J.M. Castaldelli-Maia, A. Ventriglio, The outbreak of COVID-19 coronavirus and its impact on global mental health, Int J Soc Psychiatry 66 (4) (2020) 317–320.
[3] B. Pfefferbaum, C.S. North, Mental health and the Covid-19 pandemic, N. Engl. J. Med. 383 (6) (2020) 510–512.
[4] Orgnaziation for Economic Cooperation and Development, Health at a Glance 2019, Paris, 2019.
[5] M. Ueda, R. Nordstrom, T. Matsubayashi, Suicide and mental health during the COVID-19 pandemic in Japan, J Public Health (Oxf) 44 (3) (2022) 541–548.
[6] C.J. Caspersen, K.E. Powell, G.M. Christenson, Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research, Public Health Rep. 100 (2) (1985) 126–131.
[7] F.B. Schuch, D. Vancampfort, J. Firth, S. Rosenbaum, P.B. Ward, E.S. Silva, M. Hallgren, A. Ponce De Leon, A.L. Dunn, A.C. Deslandes, M.P. Fleck, A. F. Carvalho, B. Stubbs, Physical activity and incident depression: a Meta-analysis of prospective cohort studies, Am. J. Psychiatry 175 (7) (2018) 631–648.
[8] S.J. Strath, L.A. Kaminsky, B.E. Ainsworth, U. Ekelund, P.S. Freedson, R.A. Gary, C. R. Richardson, D.T. Smith, A.M. Swartz, L. American Heart Association Physical Activity Committee of the Council on, H. Cardiometabolic, E.C.R. Cardiovascular, C. Prevention Committee of the Council on Clinical, Council, Guide to the assessment of physical activity: clinical and research applications: a scientific statement from the American Heart Association, Circulation 128 (20) (2013) 2259–2279.
[9] B.E. Yates, M.C. DeLetter, E.M. Parrish, Prescribed exercise for the treatment of depression in a college population: an interprofessional approach, Perspect Psychiatr Care 56 (4) (2020) 894–899.
[10] S. Wolf, B. Seiffer, J.-M. Zeibig, J. Welkerling, L. Brokmeier, B. Atrott, T. Ehring, F. B. Schuch, Is physical activity associated with less depression and anxiety during the COVID-19 pandemic? A rapid systematic review, Sports Med 51 (2021) 1771–1783.
[11] D. Jiménez-Pavón, A. Carbonell-Baeza, C. Lavie, Physical exercise as therapy to fight against the mental and physical consequences of COVID-19 quarantine: special focus in older people, Prog Cardiovasc Di 1862 (2) (2020), 183135.
[12] R. López-Bueno, J. Calatayud, Y. Ezzatvar, J.A. Casajús, L. Smith, L.L. Andersen, G. F. López-Sánchez, Association between current physical activity and current perceived anxiety and mood in the initial phase of COVID-19 confinement, Front. Psychiatr. 11 (729) (2020).
[13] S. Schrempft, M. Jackowska, M. Hamer, A. Steptoe, Associations between social isolation, loneliness, and objective physical activity in older men and women, BMC Public Health 19 (1) (2019) 1–10.
[14] G. Lindsay Smith, L. Banting, R. Eime, G. O'Sullivan, J. van Uffelen, The association between social support and physical activity in older adults: a systematic review, Int. J. Behav. Nutr. Phys. Act. 14 (1) (2017) 1–21.
[15] N. Verma, S. Rastogi, Y.C. Chia, S. Siddique, Y. Turana, H.M. Cheng, G. P. Sogunuru, J.C. Tay, B.W. Teo, T.D. Wang, K.K.F. Tsoi, K. Kario, Non-pharmacological management of hypertension, J Clin Hypertens (Greenwich) 23 (7) (2021) 1275–1283.
[16] F.D. Fuchs, P.K. Whelton, High blood pressure and cardiovascular disease, Hypertension 75 (2) (2020) 285–292.
[17] P.J. Smith, J.A. Blumenthal, M.A. Babyak, A. Georgiades, A. Hinderliter, A. Sherwood, Effects of exercise and weight loss on depressive symptoms among men and women with hypertension, J. Psychosom. Res. 63 (5) (2007) 463–469.
[18] Y. Lu, M. Lu, H. Dai, P. Yang, J. Smith-Gagen, R. Miao, H. Zhong, R. Chen, X. Liu, Z. Huang, H. Yuan, Lifestyle and risk of hypertension: follow-up of a young pre-hypertensive cohort, Int. J. Med. Sci. 12 (7) (2015) 605–612.
[19] Y.W. Kang, Y.S. Ko, Y.J. Kim, K.M. Sung, H.J. Kim, H.Y. Choi, C. Sung, E. Jeong, Korea community health survey data profiles, Osong Public Health Res. Perspect. 6 (3) (2015) 211–217.
[20] C. Shin, Y. Kim, S. Park, S. Yoon, Y.H. Ko, Y.K. Kim, S.H. Kim, S.W. Jeon, C. Han, Prevalence and associated factors of depression in general population of Korea: results from the Korea National Health and nutrition examination survey, 2014, J. Korean Med. Sci. 32 (11) (2017) 1861–1869.
[21] C. Han, S.A. Jo, J.H. Kwak, C.U. Pae, D. Steffens, I. Jo, M.H. Park, Validation of the patient health questionnaire-9 Korean version in the elderly population: the Ansan geriatric study, Compr. Psychiatry 49 (2) (2008) 218–223.
[22] B. Levis, A. Benedetti, B.D. Thombs, D.E.S.D. Collaboration, Accuracy of patient health Questionnaire-9 (PHQ-9) for screening to detect major depression: individual participant data meta-analysis, BMJ 365 (2019), l1476.
[23] M. Hagstromer, P. Oja, M. Sjostrom, The international physical activity questionnaire (IPAQ): a study of concurrent and construct validity, Public Health Nutr. 9 (6) (2006) 755–762.
[24] G. Mammen, G. Faulkner, Physical activity and the prevention of depression: a systematic review of prospective studies, Am. J. Prev. Med. 45 (5) (2013) 649–657.
[25] S. Burke, A. Carron, M. Eys, Physical activity context and university student's propensity to meet the guidelines Centers for Disease Control and Prevention/ American College of Sports Medicine, Med SciMonit 11 (4) (2005) CR171–6.
[26] M.A. Stults-Kolehmainen, R. Sinha, The effects of stress on physical activity and exercise, Sports Med. 44 (1) (2014) 81–121.

[27] T. Gildner, E. Laugier, Z. Thayer, Exercise routine change is associated with prenatal depression scores during the COVID-19 pandemic among pregnant women across the United States, PLoS One 15 (12) (2020), e0243188.
[28] H.S. Lee, D. Dean, T. Baxter, T. Griffith, S. Park, Deterioration of mental health despite successful control of the COVID-19 pandemic in South Korea, Psychiatry Res. 295 (2021), 113570.
[29] S.-Y. Park, K. Lee, Y. Um, S. Paek, I. Ryou, Association between physical activity and depressive mood among Korean adults with chronic diseases, Korean J. Fam. Med. 39 (3) (2018) 185–190.
[30] L.E. Egede, Major depression in individuals with chronic medical disorders: prevalence, correlates and association with health resource utilization, lost productivity and functional disability, Gen. Hosp. Psychiatry 29 (5) (2007) 409–416.
[31] S.M. Hegde, S.D. Solomon, Influence of physical activity on hypertension and cardiac structure and function, Curr. Hypertens. Rep. 17 (10) (2015) 77.
[32] A. Vallee, E. Wiernik, S. Kab, C. Lemogne, M. Goldberg, M. Zins, J. Blacher, Association of depressive symptoms and socioeconomic status in determination of blood pressure levels and hypertension: the CONSTANCES population based study, J. Affect. Disord. 279 (2021) 282–291.
[33] B. Barone Gibbs, M.-F. Hivert, G.J. Jerome, W.E. Kraus, S.K. Rosenkranz, E. N. Schorr, N.L. Spartano, F. Lobelo, A.H.A.C.o. Lifestyle, C. Health, C.o. Cardiovascular, S. Nursing, C.o.C. Cardiology, Physical activity as a critical component of first-line treatment for elevated blood pressure or cholesterol: who, what, and how?: a scientific statement from the American Heart Association, Hypertension 78 (2) (2021) e26–e37.
[34] N.C.D.R.F. Collaboration, Worldwide trends in hypertension prevalence and progress in treatment and control from 1990 to 2019: a pooled analysis of 1201 population-representative studies with 104 million participants, Lancet 398 (10304) (2021) 957–980.