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Association between self-reported physical activity and indicators of cardiovascular risk in community-dwelling older adults with hypertension in Korea

A cohort study

Jeong-Ah Ahn, PhD, RN[a], Deulle Min, PhD, RN[b,*]

Abstract

The prevalence of hypertension has increased with the rise in the elderly population, and high blood pressure is a major cause of cardiovascular disease. Physical activity is an important strategy for preventing cardiovascular disease. The study aimed to explore the association between physical activity and cardiovascular risk indicators in community-dwelling older adults with hypertension.

This study is a secondary data analysis of a prospective longitudinal study using data from the Elderly Cohort Database of the National Health Insurance Service in South Korea between 2002 and 2013. Participants included 10,588 older adults (≥60 years) with hypertension. Data assessing self-reported physical activity and directly measured blood pressure, fasting blood glucose, body mass index, and total cholesterol levels throughout the 12-year study were extracted from the original database and analyzed. Participants were categorized into 4 groups based on the reported changes in physical activity over time: Group I (Maintaining No Physical Activity Group), II (Changing from No Physical Activity to Physical Activity Group), III (Changing from Physical Activity to No Physical Activity Group), and IV (Maintaining Physical Activity Group). Cox proportional hazard model was used to confirm the risk of cardiovascular indicators over time in each group.

Participants' mean age was 64.2 years in the initial year of 2002. The number of participants in Groups I, II, III, and IV was 4032, 2697, 1919, and 1940, respectively. Group IV showed a significant decline in risk for uncontrolled hypertension compared to Group I (hazard ratio = 0.87, 95% confidence interval [0.800–0.948]). Group II showed a significant decrease in risk for uncontrolled diabetes compared to Group I (hazard ratio = 0.94, 95% confidence interval [0.888–0.999]).

The findings indicated that physical activity is a significant factor associated with indicators of cardiovascular risk in older people with high blood pressure. Healthcare providers should be aware of the importance of older adults' physical activity and encourage them to perform and maintain it steadily for better long-term cardio-metabolic outcomes.

Abbreviations: BMI = body mass index, BP = blood pressure, CVD = cardiovascular disease.

Keywords: aged, cardiovascular diseases, hypertension, older adults, physical activity

Editor: Maya Saranathan.

This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIT) (No. NRF-2019R1F1A1063148) and research grant in 2019 from the Department of Nursing Science, Graduate School, Ajou University.

Patient consent is not applicable.

The authors have no conflicts of interest to disclose.

The data that support the findings of this study are available from National Health Insurance Service but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of National Health Insurance Service (https://nhiss.nhis.or.kr/bd/ab/bdaba001cv.do).

[a] College of Nursing and Research Institute of Nursing Science, Ajou University, Suwon, Republic of Korea, [b] Department of Nursing, College of Medicine, Wonkwang University, Iksan, Republic of Korea.

[*] Correspondence: Deulle Min, Department of Nursing, College of Medicine, Wonkwang University, 460, Iksandae-ro, Iksan, Jeonbuk 54538, Republic of Korea (e-mail: dlmin20@wku.ac.kr).

How to cite this article: Ahn JA, Min D. Association between self-reported physical activity and indicators of cardiovascular risk in community-dwelling older adults with hypertension in Korea: a cohort study. Medicine 2021;100:34(e27074).

Received: 3 May 2021 / Received in final form: 27 July 2021 / Accepted: 12 August 2021

http://dx.doi.org/10.1097/MD.0000000000027074

1. Introduction

The population of older adults is expected to grow from 900 million, representing approximately 12% of the world's population, in 2015 to 2 billion, approximately 22% of the world's population, in 2050 worldwide.[1] South Korea is one of the rapidly becoming aging societies. In 1980, the number of older adults accounted for only 3.8% of South Korea's population, but in 2019, it reached 15.7%, with the percentage expected to rise to 33.9% in 2040 and 46.5% in 2067.[2] Consistent with the increase in the older population, the prevalence of chronic diseases has risen. A 2008 survey of older adults reported that the average number of chronic diseases in this population was 2.1,[3] which increased to 2.7 in 2017.[4] In particular, the prevalence of hypertension in older adults had increased to 59% in 2017, indicating that over half of older adults in Korea have high blood pressure (BP).[4]

Hypertension is the most common chronic disease among adults and older people, with 1.13 billion worldwide, and is considered the most common and powerful risk factor for developing cardiovascular disease (CVD).[5,6] CVD is the leading cause of death globally, accounting for 31% of deaths worldwide in 2016.[7] The risk factors for CVD include increased age, smoking, alcohol consumption, obesity, hypertension, diabetes, dyslipidemia, and sedentary lifestyle.[8,9]

Physical activity is considered an essential recommendation for BP control in patients with hypertension. The physical activity or exercise regimen recommended for hypertension patients includes at least 30 minutes of moderate-intensity aerobic exercise daily, or almost daily, or at least 150 minutes a week.[10,11] The importance of physical activity was supported in a meta-analysis of 27 interventions with patients diagnosed with hypertension.[12,13] For example, 1 intervention reported that physical activity (i.e., aerobic training) in 52 postmenopausal women with hypertension (mean age of 64 years) significantly decreased systolic BP over 12 weeks.[14] Another study compared the cardiovascular risks of men with hypertension who played 1 hour of soccer twice a week and men who did not, showing that systolic and diastolic BPs in the soccer group decreased by 12 mm Hg and 8 mm Hg, respectively, over 6 months.[15] A longitudinal study in Australia ($N=10,339$, 1996–2010) examining the impact of body mass index (BMI) and physical activity on the occurrence of hypertension in healthy women found that increased BMI and decreased physical activity were associated with increased risk for high BP.[16] In addition, a longitudinal analysis ($N=502,635$ people with a 5.4–6.8 year follow-up) estimated the association between grip strength, objective and subjective physical activity, CVD, and all-cause death in a large cohort of the British Biobank and reported that exercise and physical activity were associated with a reduced incidence of CVD.[17]

However, to date, limited research has examined the initial effects of physical activity on relatively healthy people. This study aimed to determine the longitudinal effects of physical activity on CVD risk factors in older people with a prior diagnosis of hypertension. For physically independent older adults in the community, measuring daily physical activity rather than the amount of short-term exercise during their participation in an intervention program is important.[18] Furthermore, most studies of community-based physical activity intervention have yet to explore long-term effects that extend beyond a year.[13] Therefore, this study's objective was to explore the long-term effects of physical activity on CVD indicators in community-dwelling hypertensive older adults.

2. Materials and methods

2.1. Study design and participants

Secondary analysis of a prospective longitudinal study was conducted using the Elderly Cohort Data of the National Health Insurance Service in South Korea between 2002 and 2013. This representative survey in Korea was originally designed to analyze the risk factors and prognosis of senile diseases and included socioeconomic information, hospital-use history, and diverse health examination results.

The participants in this study were 10,588 older adults (≥60 years) with hypertension. This Elderly Cohort Data surveyed the number of days of physical activity per week from 2002 to 2008, and the number of days participants engaged in intense, moderate, and walking activity per week from 2009 to 2013. Regardless of time and intensity, we identified physical activity as either *yes* or *no*, with participants being classified as *yes* if they reported the number of days of intense and moderate physical activity participation per week for at least 1 day from 2009 to 2013, and *no* if the number of days of participation was reported as 0. Participants were categorized into 4 groups by their changes in physical activity presence or not over time. Group I included the people who self-reported that they did not engage in physical activity in their daily life throughout the assessment period of 2002 to 2013 and was called the Maintaining No Physical Activity Group. Group II included those who did not engage in physical activity in 2002 but began to participate in physical activity by 2013 referred to as the Changing from No Physical Activity to Physical Activity Group. Group III included those who self-reported that they were physically active in 2002 but did not sustain their participation in physical activity when assessed in 2013, labeled the Changing from Physical Activity to No Physical Activity Group. Finally, Group IV included those who self-reported remaining physically active throughout 2002 to 2013 and was called the Maintaining Physical Activity Group.

2.2. Variables

As for CVD indicators, we extracted variables of BP, blood glucose, BMI, and total cholesterol levels for 12 years from the database.

2.2.1. Blood pressure. BP was measured as systolic/diastolic pressure (mm Hg) on the participants. According to the European Society of Hypertension, BP over 160/100 mm Hg is considered Stage 2 (more severe) hypertension[19]; therefore, having either a measurement of SBP over 160 mm Hg or DBP over 100 mm Hg was used to indicate uncontrolled BP in this study.

2.2.2. Blood glucose. In the cohort survey, pre-meal plasma glucose was checked in 2002 to 2010, and fasting plasma glucose was measured in 2011 to 2013. Blood glucose was considered to be controlled if it was less than 100 mg/dL,[20] so blood glucose greater than 100 mg/dL was categorized as uncontrolled glucose in this study.

2.2.3. Body mass index. Height (cm) and weight (kg) were measured on the participants. BMI was calculated from the data and was categorized as being normal or obese using the cutoff value of 25 kg/m^2.[21]

2.2.4. Total cholesterol. Total cholesterol level was measured for the participants. Participants were categorized as normal or having hypercholesterolemia using the cutoff value of 200 mg/dL.[9]

2.2.5. Covariates. Age, gender, and economic status were identified as demographic characteristics. Economic status was divided into 4 groups, according to the 25% quartile: Low, Low-Medium, High-Medium, and High. As characteristics of health behaviors, smoking and alcohol use were classified as *yes* if participants reported currently engaging in either behavior, and *no* if they did not. The number of comorbidities and family history of related diseases (i.e., hypertension, diabetes, heart disease, and cerebral disease) were included as disease-related characteristics.

2.3. Data analyses

Data cleaning and analysis was performed using SPSS version 23.0 (IBM SPSS Statistics, Armonk, NY). Changes in physical activity were reported as 1 if there was physical activity and 0 if there was none, and the time until the first change in physical activity was coded as a new variable. Demographic characteristics, health behaviors, and disease-related characteristics in 2002 were reported using descriptive statistics, such as frequency (percentage) and mean (standard deviation). Chi-square tests and one-way ANOVA were used to analyze differences among the physical activity groups. In addition, the Kaplan-Meier method was used to analyze the time to change from controlled to uncontrolled for BP and glucose level and from normal to high for BMI and total cholesterol level. The significance of the analyzed curves was tested using the log-rank test. A Cox proportional hazard model was also used to confirm the risk of cardiovascular indicators over time in each group.

2.4. Ethical considerations

This study was approved by the institutional review board of Ajou University (IRB No. AJIRB-SBR-EXP-19-127). After receiving approval, a request was made to access the Elderly Cohort Data to the National Health Insurance Data Sharing Services. All data were de-identified before conducting the analysis, so personal identification was protected.

3. Results

3.1. General characteristics of physical activity groups at baseline

At baseline in 2002, the mean ages of Group I (Maintaining No Physical Activity Group), II (Changing from No Physical Activity to Physical Activity Group), III (Changing from Physical Activity to No Physical Activity), and IV (Maintaining Physical Activity Group) were 64.58, 64.05, 64.13, and 63.67 years, respectively. Group IV was significantly younger than the other 3 groups ($F=24.43$, $P<.001$). Women in Groups I, II, III, and IV represented 58.9%, 54.8%, 39.4%, and 35.5% of the sample, respectively ($\chi^2=401.00$, $P<.001$). Regarding economic status, people with high economic status in Groups I, II, III, and IV accounted for 23.9%, 25.6%, 31.9%, and 35.1%, respectively ($\chi^2=116.66$, $P<.001$). In addition, there were differences in smoking ($\chi^2=57.32$, $P<.001$) and alcohol consumption ($\chi^2=199.16$, $P<.001$) between the physical activity groups.

The mean number of comorbidities ranged from 0.20 to 0.24 across the 4 groups, and individuals in Group III and IV had significantly more diseases ($F=3.99$, $P=.008$). Further, the prevalence of family history of hypertension ($\chi^2=42.87$, $P<.001$), diabetes ($\chi^2=32.37$, $P<.001$), heart disease ($\chi^2=19.65$, $P<.001$), and cerebral disease ($\chi^2=43.95$, $P<.001$) were significantly higher for those in Group III and IV than those in Group I and II (Table 1).

3.2. Comparison of cardiovascular indicators between physical activity groups at baseline and after 12 years

No significant differences were found in the rates of uncontrolled systolic BP (19.7%–22.2%) across 4 groups at baseline; however, the rates of uncontrolled systolic BP were significantly different between the groups after 12 years ($\chi^2=17.07$, $P<.001$). Group IV had the lowest rate (4.6%) of uncontrolled systolic BP, and Group I had the highest (7.1%). There were no significant differences in the rates of uncontrolled diastolic BP (19.3%–20.0%) across the 4 groups at baseline; however, the rates of uncontrolled diastolic BP were significantly different across the groups after 12 years ($\chi^2=10.89$, $P=.01$). Group IV had the lowest rate (2.6%) of uncontrolled diastolic BP, and Group I had the highest (3.9%).

As for the glucose level, there were significant differences between the 4 groups both at baseline ($\chi^2=9.00$, $P=.03$) and after 12 years ($\chi^2=10.37$, $P=.02$). Regarding BMI, there were also significant differences between the 4 groups at baseline ($\chi^2=11.61$, $P=.009$) and after 12 years ($\chi^2=16.57$, $P<.001$). BMI was significantly higher in Group III and IV than in Group I and II at baseline and after 12 years.

Regarding total cholesterol level, no significant differences in the rates of hypercholesterolemia (53.0%–55.4%) between 4 groups at baseline were found; however, the rates of hypercholesterolemia significantly differed between the groups after 12 years ($\chi^2=19.05$, $P<.001$). Group IV had the lowest rate (30.0%) of hypercholesterolemia, and Group I had the highest (35.5%; Table 2).

3.3. Associations of physical activity with cardiovascular indicators

We examined the longitudinal associations of physical activity and BP, glucose, BMI, and total cholesterol levels of the participants using the Kaplan-Meier analysis (Figs. 1 and 2). The length of time for changing from controlled to uncontrolled BP and glucose was significantly different between the 4 groups. Specifically, the length of time for changing to uncontrolled BP was significantly longer in Group IV than in Group I (7.72 years; $\chi^2=16.56$, $P=.001$), and the length of time to change to uncontrolled glucose was significantly longer in Group II than in Group I ($\chi^2=15.77$, $P=.001$).

As the results of the Cox proportional hazard model (Table 3), after adjusting for the covariates (i.e., age, gender, economic status, smoking, alcohol consumption, number of comorbidities, and family history), those in Group IV had 12.9% lower risk of having uncontrolled BP than those in Group I (hazard ratio = 0.871, 95% confidence interval = [0.800–0.948]). In addition, those in Group II had a 5.8% lower risk of having uncontrolled glucose than those in Group I (hazard ratio = 0.942, 95% confidence interval = [0.888–0.999]).

Table 1

Comparison of general characteristics between physical activity groups at baseline ($N = 10,588$).

Characteristics	Group I[a] ($n = 4032$)	Group II[b] ($n = 2697$)	Group III[c] ($n = 1919$)	Group IV[d] ($n = 1940$)	F or χ^2	P (Scheffè)
	M (SD) or n (%)[*]					
Age	64.58 (4.26)	64.05 (3.97)	64.13 (3.98)	63.67 (3.65)	24.43	<.001 (d < b, c < a)
Gender						
Men	1657 (41.1)	1219 (45.2)	1162 (60.6)	1251 (64.5)	401.00	<.001
Women	2375 (58.9)	1478 (54.8)	757 (39.4)	689 (35.5)		
Economic status						
Low	1078 (26.7)	701 (26.0)	492 (25.6)	451 (23.2)	116.66	<.001
Lower middle	1114 (27.6)	742 (27.5)	415 (21.6)	430 (22.2)		
Upper middle	878 (21.8)	563 (20.9)	400 (20.8)	378 (19.5)		
High	962 (23.9)	691 (25.6)	612 (31.9)	681 (35.1)		
Smoking						
Yes	835 (21.3)	513 (19.6)	506 (27.5)	495 (26.4)	57.32	<.001
No	3090 (78.7)	2108 (80.4)	1336 (72.5)	1378 (73.6)		
Alcohol consumption						
Yes	1185 (29.7)	820 (30.7)	791 (41.9)	866 (45.3)	199.16	<.001
No	2803 (70.3)	1849 (69.3)	1099 (58.1)	1044 (54.7)		
Number of comorbidities	0.22 (0.45)	0.20 (0.43)	0.23 (0.47)	0.24 (0.48)	3.99	.008 (b < c, d)
Family history						
Hypertension						
Yes	264 (7.5)	214 (9.2)	201 (12.1)	202 (12.2)	42.87	<.001
No	3248 (92.5)	2122 (90.8)	1455 (87.9)	1459 (87.8)		
Diabetes						
Yes	102 (2.9)	90 (3.9)	88 (5.3)	97 (5.9)	32.37	<.001
No	3390 (97.1)	2235 (96.1)	1563 (94.7)	1544 (94.1)		
Heart disease						
Yes	52 (1.5)	50 (2.2)	56 (3.4)	39 (2.4)	19.65	<.001
No	3433 (98.5)	2270 (97.8)	1591 (96.6)	1601 (97.6)		
Cerebral disease						
Yes	130 (3.7)	97 (4.2)	105 (6.4)	124 (7.5)	43.95	<.001
No	3362 (96.3)	2231 (95.8)	1545 (93.6)	1524 (92.5)		

Group I: Maintaining No Physical Activity Group; Group II: Changing from No Physical Activity to Physical Activity Group; Group III: Changing From Physical Activity to No Physical Activity Group; Group IV: Maintaining Physical Activity Group.

[*] Excluded no response.

4. Discussion

This secondary data analysis of a prospective longitudinal study examined the benefits of physical activity over 12 years on the cardiovascular risk factors in a sample of older adults with hypertension living in the community. Our results demonstrated that the group with consistent and more physical activity had a significantly lower risk of having uncontrolled BP than the group who did not engage in any specific physical activity over 12 years. In addition, the group whose physical activity level changed from no physical activity to engaging in physical activity showed a lower risk of having uncontrolled glucose levels than the group that did not engage in any physical activity over 12 years.

These results support previous research indicating that regular physical activity can lower BP and blood glucose and reduce CVD risks.[13,22–24] Oxygen, supplied to the body during physical activity, strengthens the muscles of the cardiovascular system and is effective in improving peripheral vascular resistance associated with CVD indicators, such as hypertension and diabetes.[25] A recent study examined the effects of physical activity on CVD and mortality that used data from 17 countries and 130,843 people and concluded that all types of physical activity could effectively reduce CVD risks and overall mortality.[26]

The characteristic feature of a long-term hypertensive heart is a compensatory increase in left ventricular wall thickness (hypertrophy) that is also considered to be an independent predictor of uncontrolled hypertension.[23] If this condition persists, chronic pressure overload can lead to concentric left ventricular hypertrophy, compensatory insufficiency, and subsequent chronic heart failure and CVD events.[27] Although the exact mechanism for this process has yet to be identified, physical activity can help prevent left ventricular hypertrophy or advanced paradoxical regression in those with hypertension.[23] A study of 454 adults from 17 hypertension units (aged 18–45 years; 281 sedentary vs 173 active) with a long-term (median follow-up of 8.3 years) prospective observation showed that sustained regular physical activity significantly decreased BP and prevented the development of left ventricular hypertrophy.[28] In the present study, both those who constantly participated in physical activity and those who changed from being inactive to engaging in physical activity showed beneficial results related to glucose control, one of the CVD indicators. Therefore, healthcare providers should emphasize the importance of sustained regular physical activity and encourage those who are not engaged in physical activity to begin participating in physical activity, as it is a critical strategy for controlling high BP and reducing the risk factors of CVD in older adults with hypertension.

However, in this study, we did not identify clear evidence of the effects of physical activity on obesity or hypercholesterolemia. In a previous study investigating the relationship between BMI and mortality rate in a sample of older adults, the mortality rate was higher when the BMI was less than 23.0 kg/m^2 or higher than

Table 2

Comparison of cardiovascular indicators among physical activity groups at baseline and after 12 years (N = 10,588).

Cardiovascular indicators	Group I[a] (n = 4032)	Group II[b] (n = 2697)	Group III[c] (n = 1919)	Group IV[d] (n = 1940)	F or χ^2	P (Scheffé)
	M ± SD or n (%)					
Systolic blood pressure (mm Hg)						
Baseline	148.22 (14.38)	147.91 (14.25)	147.24 (13.81)	147.31 (14.42)	3.00	.029 (c, d < a)
<160	3137 (77.8)	2114 (78.4)	1525 (79.5)	1558 (80.3)	5.69	.128
≥160	894 (22.2)	583 (21.6)	394 (20.5)	382 (19.7)		
After 12 yr	132.64 (15.76)	132.84 (14.96)	132.69 (15.34)	132.54 (14.61)	0.17	.920
<160	3741 (92.9)	2550 (94.5)	1803 (94.0)	1850 (95.4)	17.07	<.001
≥160	288 (7.1)	147 (5.5)	115 (6.0)	90 (4.6)		
Diastolic blood pressure (mm Hg)						
Baseline	89.97 (9.50)	89.94 (9.33)	90.02 (9.18)	90.41 (9.32)	1.22	.301
<100	3255 (80.7)	2158 (80.0)	1543 (80.4)	1555 (80.2)	0.64	.887
≥100	776 (19.3)	539 (20.0)	376 (19.6)	385 (19.8)		
After 12 yr	78.25 (10.05)	78.37 (9.53)	77.62 (9.92)	77.49 (9.57)	4.84	.002 (d < a, b)
<100	3870 (96.1)	2622 (97.2)	1857 (96.8)	1890 (97.4)	10.89	.012
≥100	159 (3.9)	75 (2.8)	61 (3.2)	50 (2.6)		
Glucose (mg/dL)						
Baseline	101.06 (33.75)	101.28 (36.23)	102.79 (33.38)	102.02 (36.43)	1.24	.292
<100	2445 (60.8)	1691 (62.8)	1120 (58.4)	1171 (60.5)	9.00	.029
≥100	1579 (39.2)	1003 (37.2)	797 (41.6)	765 (39.5)		
After 12 yr	106.58 (28.18	105.84 (26.94)	107.86 (27.34)	107.33 (25.79)	2.41	.065
<100	1960 (48.6)	1335 (49.5)	883 (46.0)	884 (45.6)	10.37	.016
≥100	2072 (51.4)	1362 (50.5)	1035 (54.0)	1055 (54.4)		
Body mass index (kg/m^2)						
Baseline	24.59 (3.11)	24.46 (2.96)	24.77 (2.86)	24.81 (2.78)	7.05	<.001 (b < c, d)
<25	2283 (56.9)	1580 (58.7)	1037 (54.4)	1058 (54.8)	11.61	.009
≥25	1730 (43.1)	1110 (41.3)	871 (45.6)	873 (45.2)		
After 12 yr	24.05 (3.30)	23.98 (3.09)	24.28 (3.04)	24.30 (2.96)	6.21	<.001 (a, b < c, d)
<25	2543 (63.4)	1763 (65.7)	1168 (61.1)	1172 (60.6)	16.57	<.001
≥25	1466 (36.6)	920 (34.3)	743 (38.9)	763 (39.4)		
Total cholesterol (mg/dL)						
Baseline	205.84 (39.64)	206.40 (40.11)	206.20 (38.46)	205.07 (38.33)	0.47	.702
<200	1870 (46.5)	1203 (44.6)	892 (46.5)	909 (47.0)	3.42	.332
≥200	2153 (53.5)	1493 (55.4)	1025 (53.5)	1024 (53.0)		
After 12 yr	187.69 (39.37)	187.22 (37.80)	184.38 (38.99)	183.13 (36.90)	8.20	<.001 (c, d < a, b)
<200	2601 (64.5)	1760 (65.3)	1285 (67.0)	1356 (70.0)	19.05	<.001
200≤	1,431 (35.5)	937 (34.7)	633 (33.0)	582 (30.0)		

Group I = Maintaining No Physical Activity Group, Group II = Changing from No Physical Activity to Physical Activity Group, Group III = Changing From Physical Activity to No Physical Activity Group, Group IV = Maintaining Physical Activity Group.

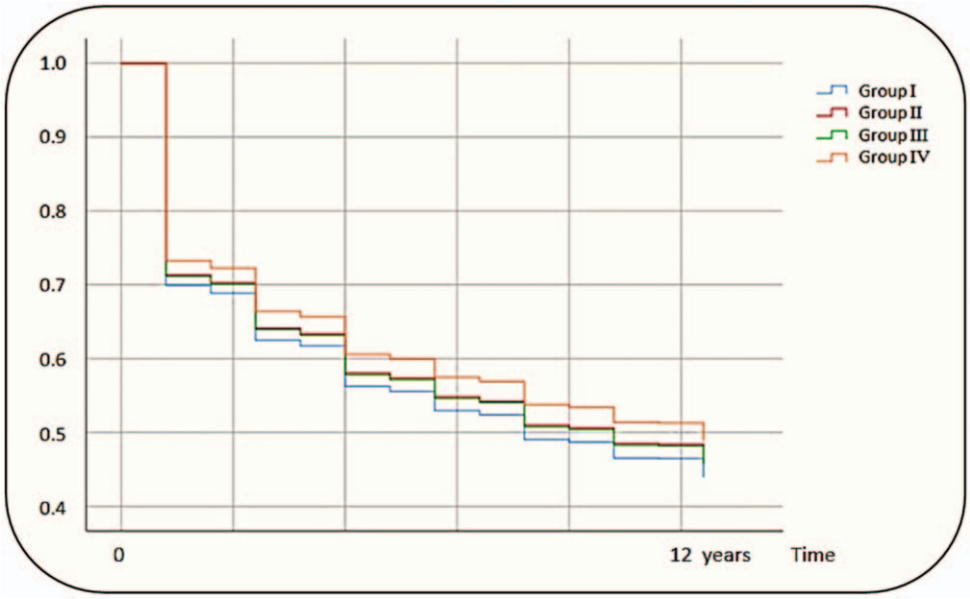

Figure 1. Uncontrolled blood pressure changes over time.

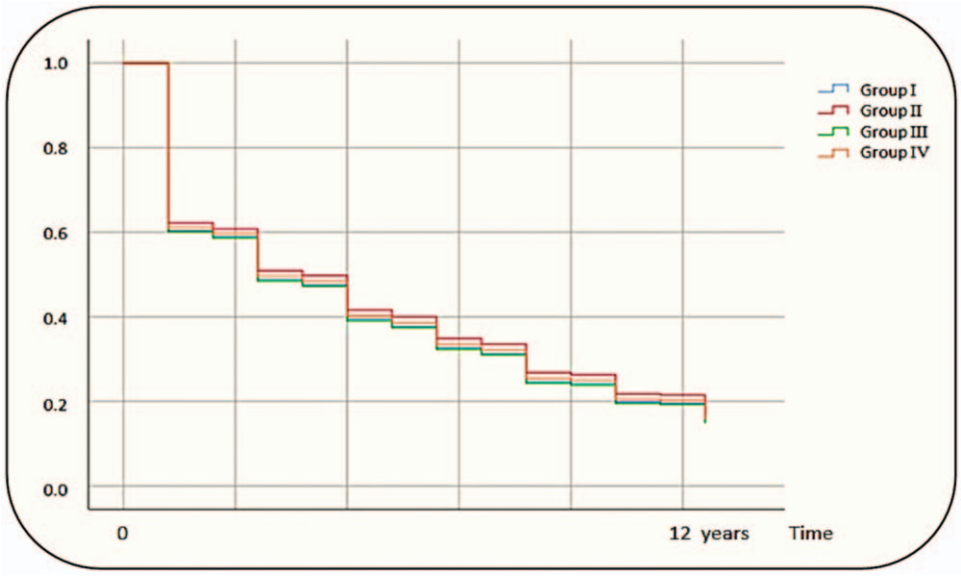

Figure 2. Uncontrolled glucose changes over time.

33.0 kg/m^2.[29] Therefore, follow-up studies are needed to identify the recommended BMI range that can be sustained with adequate daily physical activity and prevent the occurrence of CVD in older people with high BP. Low-dose cholesterol medications are commonly used by patients with hypertension since they reduce CVD and atherosclerotic risks.[30] Our sample included older adults diagnosed with hypertension; thus, they may have been prescribed cholesterol-lowering medications along with anti-hypertensive medications, which could have biased the results of this study. Additional research is needed that controls for the effects of diverse medications taken by the population of older adults.

This study has several limitations. First, this was secondary data analysis, and the responses about physical activity were self-reported by older adults so that they may have been inaccurate or varied from their actual physical activity status. In addition, the quality and quantity of physical activity were not included as the variables used to assess physical activity changes over time. Second, this study did not include information on the participants' use of medical facilities, such as hospital visits, and information on medication use. Research should be conducted that examines the diverse methods of treating hypertension in the older adult population. Regardless, this study's strength is the emphasis on the benefits of physical activity as a non-pharmacological intervention by investigating the associations on CVD indicators over a period of 12 years in a sample of older adults with hypertension living in the community.

Table 3

Effects of physical activity on cardiovascular indicators in older adults with hypertension.

Cardiovascular indicators	Adjusted† HR	95% CI
Uncontrolled blood pressure		
Group I (reference)		
Group II	0.946	0.880–1.017
Group III	0.952	0.877–1.033
Group IV	0.871**	0.800–0.948
Uncontrolled glucose		
Group I (reference)		
Group II	0.942*	0.888–0.999
Group III	1.011	0.947–1.080
Group IV	0.979	0.915–1.046
Obesity		
Group I (reference)		
Group II	0.948	0.883–1.017
Group III	1.056	0.976–1.143
Group IV	1.052	0.971–1.139
Hypercholesterolemia		
Group I (reference)		
Group II	1.007	0.950–1.069
Group III	1.038	0.971–1.110
Group IV	1.028	0.960–1.100

Group I = Maintaining No Physical Activity Group, Group II = Changing From No Physical Activity to Physical Activity Group, Group III = Changing From Physical Activity to No Physical Activity Group, Group IV = Maintaining Physical Activity Group.
CI = confidence interval, HR = hazard ratio.
† Adjusted for age, gender, economic status, smoking, alcohol consumption, number of comorbidities, and family history.
* $P < .05$.
** $P < .01$.

5. Conclusions

The results of this study demonstrated that physical activity is significantly associated with indicators of cardiovascular risk in older people with hypertension. Healthcare providers should be aware of the importance of older adults' physical activity and encourage them to perform and maintain it steadily for better long-term cardio-metabolic outcomes.

Author contributions

Conceptualization: Jeong-Ah Ahn
Data curation: Jeong-Ah Ahn and Deulle Min
Formal analysis: Jeong-Ah Ahn and Deulle Min
Funding acquisition: Jeong-Ah Ahn
Methodology: Jeong-Ah Ahn and Deulle Min

Supervision: Jeong-Ah Ahn and Deulle Min
Writing – original draft: Jeong-Ah Ahn and Deulle Min
Writing – review & editing: Jeong-Ah Ahn and Deulle Min

References

[1] World Health Organization. Ageing and health. Available at: https://www.who.int/news-room/fact-sheets/detail/ageing-and-health. Accessed January 4, 2021.
[2] Korea Statistical Information Service. Estimated population by major age group (production age population, elderly population, etc.)/nationwide. Available at: https://kosis.kr/statHtml/statHtml.do?orgId=101&tblId=DT_1BPA003&vw_cd=&list_id=&scrId=&seqNo=&lang_mode=ko&obj_var_id=&itm_id=&conn_path=B1&path=%252Fconts%252FnsportalStats%252FnsportalStats_0102Body.jsp. Accessed December 8, 2020.
[3] Ministry of Health and Welfare. 2008 Elderly Survey. Available at: http://www.mohw.go.kr/react/jb/sjb030301vw.jsp?PAR_MENU_ID=03&MENU_ID=032901&CONT_SEQ=336618. Accessed December 08, 2020.
[4] Ministry of Health and Welfare. 2017 Elderly Survey. Available at: http://www.mohw.go.kr/react/jb/sjb030301vw.jsp?PAR_MENU_ID=03&MENU_ID=032901&page=1&CONT_SEQ=344953. Accessed December 08, 2020.
[5] Schuler G, Adams V, Goto Y. Role of exercise in the prevention of cardiovascular disease: results, mechanisms, and new perspectives. Eur Heart J 2013;34:1790–9.
[6] World Health Organization. Hypertension. Available at: https://www.who.int/news-room/fact-sheets/detail/hypertension. Accessed December 08, 2020.
[7] World Health Organization. Cardiovascular diseases. Available at: https://www.who.int/news-room/fact-sheets/detail/cardiovascular-diseases-(CVDs). Accessed December 09, 2020.
[8] Brunzell JD, Davidson M, Furberg CD, et al. Lipoprotein management in patients with cardiometabolic risk: consensus statement from the American Diabetes Association and the American College of Cardiology Foundation. Diabetes Care 2008;31:811–22.
[9] Nelson RH. Hyperlipidemia as a risk factor for cardiovascular disease. Prim Care 2013;40:195–211.
[10] James PA, Oparil S, Carter BL, et al. 2014 evidence-based guideline for the management of high blood pressure in adults: report from the panel members appointed to the Eighth Joint National Committee (JNC 8). JAMA 2014;311:507–20.
[11] Pescatello LS, MacDonald HV, Ash GI, et al. Assessing the existing professional exercise recommendations for hypertension: a review and recommendations for future research priorities. Mayo Clin Proc 2015;90:801–12.
[12] Williams PT, Thompson PD. Walking versus running for hypertension, cholesterol, and diabetes mellitus risk reduction. Arterioscler Thromb Vasc Biol 2013;33:1085–91.
[13] Börjesson M, Onerup A, Lundqvist S, Dahlöf B. Physical activity and exercise lower blood pressure in individuals with hypertension: narrative review of 27 RCTs. Br J Sports Med 2016;50:356–61.
[14] Arca EA, Martinelli B, Martin LC, Waisberg CB, Franco RJ. Aquatic exercise is as effective as dry land training to blood pressure reduction in postmenopausal hypertensive women. Physiother Res Int 2014;19:93–8.
[15] Krustrup P, Randers MB, Andersen LJ, Jackman SR, Bangsbo J, Hansen PR. Soccer improves fitness and attenuates cardiovascular risk factors in hypertensive men. Med Sci Sports Exerc 2013;45:553–61.
[16] Jackson C, Herber-Gast GC, Brown W. Joint effects of physical activity and BMI on risk of hypertension in women: a longitudinal study. J Obes 2014;2014:271532doi:10.1155/2014/271532.
[17] Tikkanen E, Gustafsson S, Ingelsson E. Associations of fitness, physical activity, strength, and genetic risk with cardiovascular disease: longitudinal analyses in the UK Biobank Study. Circulation 2018;137:2583–91.
[18] Hernandes NA, Probst VS, Da Silva RAJr, Januário RS, Pitta F, Teixeira DC. Physical activity in daily life in physically independent elderly participating in community-based exercise program. Braz J Phys Ther 2013;17:57–63.
[19] Mancia G, De Backer G, Dominiczak A, et al. 2007 Guidelines for the management of arterial hypertension: the Task Force for the Management of Arterial Hypertension of the European Society of Hypertension (ESH) and of the European Society of Cardiology (ESC). Eur Heart J 2007;28:1462–536.
[20] American Diabetes AssociationDiagnosis and classification of diabetes mellitus. Diabetes Care 2009;32(Suppl 1):S62–7.
[21] Weisell RC. Body mass index as an indicator of obesity. Asia Pac J Clin Nutr 2002;11(Suppl 8):S681–4.
[22] Sigal RJ, Armstrong MJ, Colby P, et al. Physical activity and diabetes. Can J Diabetes 2013;37(Suppl 1):S40–4.
[23] Hegde SM, Solomon SD. Influence of physical activity on hypertension and cardiac structure and function. Curr Hypertens Rep 2015;17:77doi:10.1007/s11906-015-0588-3.
[24] Ansah JP, Inn RLH, Ahmad S. An evaluation of the impact of aggressive hypertension, diabetes and smoking cessation management on CVD outcomes at the population level: a dynamic simulation analysis. BMC Public Health 2019;19:1105doi: 10.1186/s12889-019-7429-2.
[25] Nyberg M, Gliemann L, Hellsten Y. Vascular function in health, hypertension, and diabetes: effect of physical activity on skeletal muscle microcirculation. Scand J Med Sci Sports 2015;25(Suppl 4):S60–73.
[26] Lear SA, Hu W, Rangarajan S, et al. The effect of physical activity on mortality and cardiovascular disease in 130 000 people from 17 high-income, middle-income, and low-income countries: the PURE study. Lancet 2017;390:2643–54.
[27] Burchfield JS, Xie M, Hill JA. Pathological ventricular remodeling: mechanisms: part 1 of 2. Circulation 2013;128:388–400.
[28] Palatini P, Visentin P, Dorigatti F, et al. Regular physical activity prevents development of left ventricular hypertrophy in hypertension. Eur Heart J 2009;30:225–32.
[29] Winter JE, MacInnis RJ, Wattanapenpaiboon N, Nowson CA. BMI and all-cause mortality in older adults: a meta-analysis. Am J Clin Nutr 2014;99:875–90.
[30] Kanaki AI, Sarafidis PA, Georgianos PI, et al. Effects of low-dose atorvastatin on arterial stiffness and central aortic pressure augmentation in patients with hypertension and hypercholesterolemia. Am J Hypertens 2013;26:608–16.