Adv Health Behav, 2019, 2(1), 41-48
DOI: 10.25082/AHB.2019.01.003

RESEARCH ARTICLE

Impact of physical activity on the prevalence of hypertension among the older adults in Beijing communities

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Abstract: This study aims to evaluate the impact of physical activity (PA) on the prevalence of hypertension among older adults in Beijing community. As economy growing rapidly in China, the occurrence of hypertension increases among older people in China as well. Epidemiological studies have shown that physical activity may significantly related to lower risk of hypertension. Taking PA maybe an instructive factor to reduce the risk of being hypertensive. We randomly selected Beijing community residents aged 65 and above (n = 400), collected data comprising level of PA (low, moderate, high), blood pressure, and a host of potentially confounding variables indicated by the literature. Five logistic regression models adjusted for different modifiers were used to estimate the association between hypertension and PA. The prevalence of hypertension was 96.88%, 78.57% and 73.66% among subjects with low, moderate and high level of PA respectively. Lower diastolic BP was observed for elder people with higher level of PA ($p<0.01$). We observed a strong and statistically significant association between moderate (OR=0.09, 95% CI: 0.01 to 0.74) or high (OR=0.08, 95% CI: 0.01 to 0.57) level of PA and lower risk of hypertension ($p < 0.05$). PA is a protective factor for hypertension among older Beijing people, which suggests elderly people be encouraged to actively engage in PA, if body conditions permit.

Keywords: hypertension, physical activity, elder adults, IPAQ, Beijing

1 Introduction

By 2017, the number of patients with hypertension in China had reached 270 million. The severe complications of hypertension, including coronary stroke, coronary heart disease, heart failure and kidney disease which can potentially result in high disability and high mortality, has brought heavy burdens to families and Chinese society. However, hypertension can be prevented and controlled. Studies have shown that hypotensive therapy can reduce the risk of stroke by 35%, the risk of myocardial infarction by 20%, the risk of heart failure by more than 50%.[1] Therefore, prevention and control of hypertension is the core strategy to curb the prevalence of cardiovascular diseases in China.

There are a host of factors involved with the occurrence of hypertension. Apart from family history, the presence of hypertension is also associated with age, sex, unhealthy lifestyles such as tobacco use, physical inactivity, poor diet, and diabetes mellitus,[2] lower educational levels in elderly individuals, worse awareness, treatment and control of hypertension.[3] These factors are related with socioeconomic (SES) conditions, both at the communal and individual levels.[4] Relatively disadvantageous SES conditions including lower education, income, and net worth were associated with worse health outcome, including hypertension in old age.[5] Therefore, these factors of SES were controlled in our study.

Since the reform and opening up in 1978, the economy in China has developed rapidly and people's living standard improved remarkably. The GDP of Beijing was 10.9 billion yuan in 1978, which reached 2801.5 billion yuan in 2017.[6] However, it is doubtable that whether people's lifestyle have adapted in accordance with the economy. The unmatched adaptation of lifestyle and rapidly evolving economy may also be found in other developing countries, leaving the exploration on socioeconomic status, lifestyle and health an important research issue.

Physical activity (PA) is an important aspect of lifestyle. A number of studies have examined the effect of potentially protective measures against hypertension, including PA. PA in leisure-time and commuting was proved beneficial to the prevention and control

Received: April 16, 2019 ; **Accepted:** May 13, 2019; **Published:** May 15, 2019

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Citation: Miao H, Li J, Weng XF, *et al.* Impact of physical activity on the prevalence of hypertension among the older adults in Beijing communities. *Adv Health Behav*, 2019, **2**(1): 41-48

of hypertension, because appropriate amount of moderate PA could improve the body's capability of lowering blood pressure after exercise,[7] which was confirmed by the study of Diaz *et al*.[8] with African-American samples. However, study of the effect of PA on blood pressure lowering in the Chinese population was rare. This study explores the preventive effect of PA on hypertension among the elderly living in Beijing communities.

2 Materials and methods

2.1 Sample

With a stratified random sampling, 420 residents over 65 years old were recruited from randomly selected districts throughout Beijing in 2016. The primary sampling units were sixteen, from which five districts were randomly selected based on the functions of zones. They are Xicheng district (representing the area of capital function), Haidian and Chaoyang districts (representing the urban function extension area), Tongzhou district (representing the new area of urban development) and Mentougou district (representing the ecological reserve area). We went to a total of 19 communities from the five districts, including three in Xicheng district, seven in Haidian district, six in Chaoyang district, two in Tongzhou district and one in Mentougou district. Older residents living in these communities were invited to participate in the study anonymously. Oral informed consent was obtained from all participants.

2.2 Ethics statement

Ethics approval was obtained from the Ethics Committee in the School of Medical Humanity, Peking University (PKUSMH-JC-2017503D).

2.3 Questionnaire survey

With some modifications, we adopted the long version of International Physical Activity Questionnaire (IPAQ-L) to collect PA data.[9] Apart from that, participants were also required to answer a questionnaire on their demographics (age, education, annual household income), family history of hypertension, and smoking conditions, *etc*. The questionnaires were written in Chinese, the native language of the participants. Participants were asked to fill in the questionnaire by themselves, but if they are illiterate, the surveyors would read the content to them and record their answers. Excluding invalid questionnaires, 400 subjects (198 women and 202 men) were eligible for analysis.

2.4 Assessment of physical activities

The data of PA was provided by the participants with the adapted IPAQ-L. Items in IPAQ, PA from low- to high-intensity, were rated in four domains, including (1) leisure time PA, (2) domestic and gardening (yard) activities, (3) work-related PA, and (4) transport-related PA. Since most people in Beijing live in apartment without gardens, the domain of gardening was deleted in the questionnaire. The raw data involving PA was processed following the official instruction.[9] First, a total volume of activity was calculated by weighting vigorous-intensity activity, moderate-intensity activity and walking by their energy consuming, which was defined as metabolic equivalent of task (MET). A MET-minute value is computed by multiplying the MET score of an activity by the minutes that the activity lasts.[9] Then, according to the frequency and MET-minute of the three types of activities, the PA of participants was categorized into three levels, low, moderate and high. The criteria for the three classifications are shown in Table 1.[9]

2.5 Blood pressure measurement and definition of hypertension

Blood pressure was measured in the upper arm of seated participants after resting for at least five minutes using OMRON electronic blood pressure monitor U12 by trained surveyors. The subjects were required to be relaxed and seated quietly with both feet on the floor and the back staying straight during the measurement. We measured each participant's blood pressure twice with at least five-minute interval between each cuff inflation. The mean of the blood pressure measurements was used for the analysis. Among the 400 subjects, 103 refused to take a second measurement, 295 received measurements twice and 2 were measured for three times. Eventually, 295 people who got measurements twice were included in the final analysis. Subjects were deemed to have hypertension when their systolic blood pressure was > 140 mmHg or their diastolic blood pressure was > 90 mmHg or they reported that they were taking anti-hypertensive drugs.

2.6 Statistical analysis

The data on the questionnaires was input with EpiData, and was cross-proofed by three researchers. We used Chi-squared test to identify characteristic differences between genders (Table 2), and Chi-squared test, ANOVA and simple linear regression model were performed to explore special characteristics related to different levels of PA (Table 3). Five logistic regression models were created, four of which were adjusted for

Table 1. Criteria of PA levels

Classification	Criteria
High	a) Vigorous activity on at least 3 days achieving a total physical activity of at least 1500 MET-minutes/week OR b) Seven or more days of any combination of walking, moderate or vigorous activities achieving a minimum Total physical activity of at least 3000 MET-minutes/week.
Moderate	a) Three or more days of vigorous activity of at least 20 minutes per day OR b) Five or more days of moderate activity and/or walking of at least 30 minutes per day OR c) Five or more days of any combination of walking, moderate or vigorous activities achieving a minimum Total physical activity of at least 600 MET-minutes/week.
Low	Individuals who do not meet criteria for Categories High and Moderate.

con-founders. With PA level as the common independent variable and the dichotomous outcome of hypertension, model I was adjusted for age, model II for age and gender, model III for age, gender, family history of hypertension, and model IV for age, gender, family history of hypertension, education, annual household income and the current smoking condition. All analyses were performed in STATA 14.0.

3 Results

A total of 145 women and 150 men participated in this study (Table 2). Some heterogeneity was found between women and men, such as educational level, annual family income, smoking condition and family history of hypertension. 45.3% of older women and 58.3% of older men reported to have hypertensive parent(s). We observed no difference in age, annual household income, degree of PA, systolic blood pressure (SBP), diastolic blood pressure (DBP) and prevalence of hypertension between the two genders. Most participants were categorized under the moderate or high-level PA group; only 8.1% were least active in PA. The average SBP and DBP were 135.9±1 8.5 mmHg and 78.8± 10.2 mmHg respectively. 70.2% of subjects were identified to have hypertension.

We found PA might not be related to sex, education and family income (Table 3). However, we detected that moderate and high level of PA was significantly associated with younger age, lower SBP and DBP, and lower hypertension rate. The participants with high level of PA (73.1 years old) were seven years younger than those doing least PA (80.1 years old). Besides, the average SBP of the high group was 134.2 mmHg, 10 mmHg lower than that with least PA. The gap of DBP was not that large, but still statistically significant ($p<0.05$). Regarding the prevalence of hypertension, the difference between low and moderate levels of PA (95.8% to 69.5%) was much more substantial than that between moderate and high levels (69.5% to 66.4%).

In Table 4, we constructed five logistic regression models to examine the degree to which moderate and high level of PA could predict a lower risk of hypertension. All models indicated a statistically significant association between more PA and lower risk of hypertension ($p<0.05$). Referring to the low PA group, the unadjusted ORs of hypertension were 0.10 (95%CI: 0.01 to0.76) and 0.09 (95%CI: 0.01 to 0.66) for middle level group of PA and for high level group of PA respectively. The ORs of hypertension did not alter dramatically as the modifiers changed. In model IV, which adjusted for most confounders, including age, gender, family history of hypertension, educational level, annual household income and current smoking situation, the ORs of hypertension were 0.09 (95%CI: 0.01 to 0.74) for moderate PA and 0.08 (95%CI: 0.01 to 0.57) for most active PA.

Among the four types of PA, the proportion of leisure time PA dominates (42%) (Table 5), while the least is work-related PA (12%).

4 Discussion and Conclusion

We explored the association between PA and the prevalence of hypertension among the elder people liv-

Table 2. Characteristics of participants, by sex

Characteristics	Women (n=145)	Men (n=150)	Total (n=295)	F [a]	χ^2 [b]	*P value*
Age (Years)	74.8±6.8	73.6±6.7	74.2±6.7	2.11		0.148
65-74	72 (49.7)	87 (58.0)	159 (53.9)		2.46	0.292
75-84	61 (42.1)	50 (33.3)	111 (37.6)			
>85	12 (8.3)	13 (8.7)	25 (8.5)			
Educational level					45.88	0.000 *
No formal education	27 (18.6)	4 (2.7)	31 (10.5)			
Elementary school	59 (40.7)	34 (22.7)	93 (31.5)			
Middle school	16 (11.0)	48 (32.0)	64 (21.7)			
High school and vocational school	25 (17.2)	28 (18.7)	53 (18.0)			
Bachelor's degree and above	18 (12.4)	36 (24.0)	54 (18.3)			
Annual household income (Yuan) [c]	61800.0±55942.4	76376.9±54137.8	69463.6±55381.3	4.76		0.030 *
<20000	29 (22.5)	22 (15.4)	51 (18.8)		4.06	0.131
20000-40000	18 (14.0)	14 (9.8)	32 (11.8)			
≥40000	82 (63.6)	107 (74.8)	189 (69.5)			
Physical activity					3.72	0.155
Low	9 (6.2)	15 (10.0)	24 (8.1)			
Moderate	58 (40.0)	70 (46.7)	128 (43.4)			
High	78 (53.8)	65 (43.3)	143 (48.5)			
Smoking now [d]					36.42	0.000 *
No	134 (93.1)	96 (64.0)	230 (78.2)			
Yes	10 (6.9)	54 (36.0)	64 (21.8)			
Family history of hypertension [e]					4.81	0.028 *
No	75 (54.7)	60 (41.7)	135 (48.0)			
Yes	62 (45.3)	84 (58.3)	146 (52.0)			
Blood pressure (mmHg) [f]						
SBP	134.8±18.2	136.9±18.7	135.9±18.5	0.95		0.331
DBP	77.7±11.0	79.9±9.4	78.8±10.2	3.55		0.061
Hypertension					0.00	0.948
No	43 (29.7)	45 (30.0)	88 (29.8)			
Yes	102 (70.3)	105 (70.0)	207 (70.2)			

Note: [a] In ANOVA for continuous variables
[b] In Chi-squared test for discrete variables
[c] With 23 missing values
[d] With 1 missing value
[e] With 14 missing values
[f] With 29 missing value
* P value < 0.05

Table 3. Characteristics of participants, by levels of PA

Characteristics	Level of physical activity based on IPAQ			*P* value [a]		
	Low	Moderate	High	Low *vs.* Moderate	Moderate *vs* . High	Overall
n (%)	24 (8.1)	128 (43.4)	143 (48.5)			
Sex (% of female)	37.5	48.4	51.6	0.479	0.129	0.155
Age	80.1±8.1	74.3±6.9	73.1±5.8	0.000 *	0.118	0.000 *
Educational level (%)				0.363	0.844	0.634
No formal education	20.8	10.2	9.1			
Elementary school	37.5	30.5	31.5			
Middle school	16.7	22.7	21.7			
High school	16.7	15.6	20.3			
Bachelor's degree and above	8.3	21.1	17.5			
Annual household income (Yuan)	48895.5±38510.9 [a]	69780.5±61871.0	72505.1±51500.4 [b]	0.130	0.704	0.135
Blood pressure (mmHg)						
SBP	144.3±21.9	136.2±17.8	134.2±18.2	0.052	0.351	0.044 *
DBP	79.5±12.5	80.6±10.6	77.2±9.3 [b]	0.646	0.005	0.021 *
Hypertension (%)				0.007	0.586	0.014 *
No	4.2	30.5	33.6			
Yes	95.8	69.5	66.4			

Note: [a] Chi-squared test for sex, education and hypertension; simple linear regression for age and income (due to their heteroscedasticity); ANOVA for SBP and DBP

* P value < 0.05

Table 4. Different levels of PA and presence of hypertension

Model	Level of physical activity based on IPAQ		
	Low	Moderate	High
Crude OR (95%CI)	1	0.10 (0.01~0.76)*	0.09 (0.01~0.66)*
Adjusted OR (95%CI)			
Model I [a]	1	0.12 (0.02~0.91)*	0.11 (0.01~0.82)*
II [b]	1	0.12 (0.02~0.91)*	0.10 (0.01~0.82)*
III [c]	1	0.08 (0.01~0.69)*	0.06 (0.01~0.50)*
IV [d]	1	0.09 (0.01~0.74)*	0.08 (0.01~0.57)*

Note: [a] Adjusted for age

[b] Adjusted for age and gender

[c] Adjusted for age, gender, and family history of hypertension

[d] Adjusted for age, gender, family history of hypertension, educational level, annual household income and current smoking situation

* p<0.05

Table 5. Mean proportion of the four types of PA (METs) in total METs

Types of PA	Mean proportion in total METs (%)	Standard Errors
Leisure time PA	42.00	0.307
Domestic activities	27.42	0.254
Work-related PA	12.28	0.195
Transport-related PA	21.08	0.242

ing in Beijing communities. The primary finding of this study is the strong protective effect of active PA on hypertension, which is supportive and complementary to previous studies. And our study confirms the findings of previous studies that PA, regular aerobic PA in particular, could significantly reduce blood pressure in hypertension patientsthrough weight reduction.[10]

4.1 Education and PA

The association between higher level of PA and advantageous family income reported by previous study was not found in this study.[11] This might be attributed to two possible reasons. First, individuals living in lower SES neighborhoods are incapable of maintaining their PA in the face of inaccessible built environments.[12] Second, SES-related differences in attitudes and beliefs about healthy lifestyles (*e.g.* vigorous PA) might influence the result.[13]

4.2 Income and PA

PA was not found significantly related to educational level in this study, which is inconsistent with previous studies. For example, Papadopoulou[14] found that educational level was the only socio-economic factor associated with PA. Shaw and Spokane[15] suggested that individuals with lower educational level relied much on employment as the major source of PA, resulting in sharp declines in total PA as they retired. Further study in larger sample is needed to verify this.

4.3 Gender and Hypertension

Our study did not find the sex disparity in the prevalence of hypertension reported by previous studies.[16] Another study had similar finding, although it was focusing on the gender disparity in older people aged 65 or above in prehypertension in China.[17] As hypertension and prehypertension are on the continuum of blood pressure conditions, it is interesting to find that. We observed more cases of family history of hypertension among men than women, which were not reported by other researchers.

4.4 Income and Hypertension

Our study finds that income is not associate with hypertension among elder people, which was also found by Zhou.[18] However, other studies indicated that hypertension was more prevalent in adults with lower income than that with higher income.[19,20] Tan, *et al.*,[21] suggested that lower income might result in delayed seeking of treatment, insufficient social support and financial assistance, as well as inequity in access to essential care.

However, occupational stress, which often accompanies higher income, is one of the factors in the etiology of hypertension in modern society.[22] Therefore, stress could be included in future studies on the association between income and hypertension.

4.5 PA and chronic diseases

PA have a positive effect on a number of chronic diseases, including cardiovascular disease, diabetes, cancer, hypertension, obesity, depression and osteoporosis and metabolic syndrome-related disorders, pulmonary diseases, muscle, bone and joint diseases, and asthma.[23] It was indicated that older people with higher level of PA experienced a later onset of chronic disease compared to their sedentary counterparts, particularly for obesity and diabetes.[18] Hoseini, *et al.*[24] suggested that educational interventions had positive effect on hypertension prevention through promotion of PA practice. Our study adds evidence to the positive effect of PA. Older people should be encouraged to engage in various PA and provide them with sufficient facilities, time and space for that.

4.6 Why four types of PA measured

To our best knowledge, this study is the first research measuring comprehensive PA (not only the commuting and leisure-time PA conventionally by other studies, but also PA of working and domestic chores) of elder Chinese people and explore the relation between such comprehensive PA and hypertension in older urbanities in China. In China, doing housework occupies substantial time of elder people's life (27% of total PA in our study). Some older people choose to take a part-time job after retirement, rather than staying at home. In light of these facts, the assessment of all four types of PA is appropriate and innovative.

4.7 Limitations

Limitations of this study should be noted. First, with limited sample size, the findings may not be highly generalizable. Second, without the endorsement of the

neighborhood committees, indoors survey was not done. To some extent, this may cause sample bias, with people staying indoors unselected. Third, IPAQ was developed and tested for people aged 15-69[9] and some questions conspicuously unsuitable for the elders in Beijing deleted in our adaptation. This practice may need further research.

4.8 Conclusions

In summary, PA is a protective factor for hypertension among older Chinese urbanites living in larger cities. If body conditions permit, these elderly people should be encouraged to actively engage in PA. The significance of sufficient PA for health should be introduced in communities, especially for the elder, and better environment and suitable facilities ought to be provided for PA.

5 Conflict of Interest and Funding

Peking University Health Science Center provided a research fund to this study (PKUSMH-JC-2017503D), and the authors declare there is no conflict of interest regarding the publication of this paper.

Acknowledgement

The authors would like to thank Dr. Jun Li for his helpful advice and technical support. All the interviewees are appreciated for their participation and information provision.

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