Clinical Trial/Experimental Study

Medicine®

OPEN

Effect of long-term lifestyle intervention on mild cognitive impairment in hypertensive occupational population in China

Min Li, PhD[a], Lei Liu, MD[a], Shaowu Song, MD[b], Anshi Shi, MD[c], Yunlong Ma, MD[a], Songlin Zhang, MD[a], Zengwu Wang, MD[d], Danjun Zhu, MD[a], Gang Tian, MD[a,*]

Abstract

Background: The incidence of hypertension in China is high, which seriously affects people's health, including occupational population in mining areas. Cognitive dysfunction has a serious impact on the work and life of patients. Lifestyle intervention can improve diabetes and cardiovascular diseases. However, there are few studies on the effects of lifestyle interventions on cognitive function in hypertensive patients. So the aim of this study was to analyze the effect of long-term lifestyle intervention on mild cognitive impairment in hypertensive occupational population in China.

Methods: In September 2013, a cluster sampling was conducted for the workers in the Shaanxi Jinduicheng (intervention group) and Hancheng (control group) mining areas. In both groups, according to the blood pressure (BP) level, they were divided into hypertension stage 1 to 3 subgroups; according to their age, they were divided into between 45 and 59 and under 45 years subgroups; and according to whether or not taking medicine, they were divided into Lifestyle intervention, Lifestyle intervention plus medication, Medication, and No lifestyle intervention nor medication subgroups. The intervention group received regular lifestyle intervention for 2 years, which included diet, smoke, drink, and exercise intervention. Mild cognitive impairment was measured by the Montreal Cognitive Assessment (MoCA). The arterial stiffness was measured by Omron Automatic Atherosclerosis Tester. We conducted BP measurement and MoCA questionnaire at baseline, 6, 12, and 24 months.

Results: We analyzed a total of 510 mine workers, whose average age was 45.6 ± 13.4 years old. With the increase of BP level, the MoCA scores decreased significantly both in control and lifestyle intervention groups ($P < .05$). There was no obvious difference between the hypertensive patients whose age was between 45 and 59 to those under 45 in MoCA scores ($P > .05$). After 2 years, the BP, total cholesterol, glucose, and brachial-ankle pulse wave velocity of the Lifestyle intervention subgroup and Lifestyle intervention plus medication subgroup decreased ($P < .05$), and the MoCA scores and ankle-brachial index increased ($P < .05$), and the latter improved more significantly. Compared with the No lifestyle intervention nor medication subgroup, the BP and MoCA scores had no obvious changes at 6 months ($P > .05$), but the BP decreased and the MoCA scores increased significantly in the Lifestyle intervention and Lifestyle intervention plus medication subgroups after 1 and 2 years of lifestyle intervention ($P < .05$).

Conclusion: Long-term lifestyle intervention can be used as adjunctive therapy to improve the BP and cognitive function of hypertensive occupational population in China.

Abbreviations: ABI = ankle-brachial index, baPWV = brachial-ankle pulse wave velocity, BP = blood pressure, DBP = diastolic blood pressure, Glu = blood glucose, MCI = mild cognitive impairment, MoCA = Montreal Cognitive Assessment, SBP = systolic blood pressure, TC = total cholesterol, WHO = World Health Organization.

Keywords: hypertension, lifestyle intervention, mild cognitive impairment, occupational population

Editor: Antonino Bianco.

Min Li and Lei Liu have contributed equally to this work.

This work was supported by the National "12th Five-Year" science and technology support program "China's major cardiovascular disease investigation and key technology research" (No. 2011BAI11B01), the Natural Science Foundation of China (No. 30871042 and 81600574), the Shaanxi Province Science and Technology Research and Development Program International Science and Technology Cooperation and Exchange Project (No. 2012 kw-40-01), and the Shaanxi Province Science and Technology Research and Development Plan of Natural Science Basic Research Program (No. 2014 JM2-8145).

The authors have no conflicts of interest to disclose.

[a] Department of Cardiology, The First Affiliated Hospital of Xi'an Jiao Tong University, Xi'an, Shaanxi, China, [b] Jinduicheng Molybdenum Company Employees Hospital, [c] Hancheng Mining Bureau General Hospital, Weinan, Shaanxi, [d] Hypertension Center, Fuwai Hospital, National Center for Cardiovascular Diseases, Chinese Academy of Medical Sciences and Peking Union Medical College, Xicheng District, Xicheng District, Beijing, P. R.

[*] Correspondence: Gang Tian, Department of Cardiology, The First Affiliated Hospital, Xi'an Jiaotong University, 277 Yanta W Road, Xi'an, Shaanxi 710061, China (e-mail: tiangang@xjtu.edu.cn), or Danjun Zhu (e-mail: zhudanjun9@hotmail.com).

Medicine (2018) 97:34(e11975)

Received: 28 March 2018 / Accepted: 30 July 2018

http://dx.doi.org/10.1097/MD.0000000000011975

1. Introduction

Hypertension is a major risk factor for cardiovascular and cerebrovascular diseases, and thus constitutes a serious risk to human health. The prevalence of hypertension in China has risen rapidly between 2002 and 2012: in 2002, its prevalence in adults was 17.6%, but in 2012, it increased to 25.2%.[1] Preventing and treating hypertension can reduce the morbidity and mortality rates in the community by reducing the incidence of cardiovascular and cerebrovascular disease. Several studies show that community-based strategies to prevent and treat hypertension can be effective.[2]

The mild cognitive impairment (MCI) is a cognitive state between the normal aging and dementia. Cognitive impairment is a growing public health concern.[3] Aging, lifestyles, and chronic diseases, mainly hypertension and type 2 diabetes mellitus, are the most important contributing factors for the development and progression toward cognitive impairment.[4] The relationship between hypertension and cognitive dysfunction has been a concern, and the mechanism of hypertension-related cognitive dysfunction remains unclear.[5] Hypertension causes many pathological changes in the vascular system, and these changes may lead to cognitive dysfunction. A study found that diastolic blood pressure (DBP) increased by 10 mm Hg, the risk of cognitive decline increased by 7%, and when systolic blood pressure (SBP) > 160 mm Hg, the cognitive function was significantly reduced.[6] Both high and low blood pressures (BP) have been linked to cognitive decline. There are some evidences that antihypertensive drug treatment could play a role in the prevention of cognitive impairment through BP control. Hypertension accelerates arteriosclerotic changes in the brain, predisposing it to atheroma formation in large diameter blood vessels, and arteriolar tortuosity of small vessels of the cerebral vasculature. These vascular changes result in a reduced luminal diameter, increased resistance to flow and a decline in perfusion.[7]

A recent survey in China showed that less than one-third of adult workers have adequate BP control.[8] And the effect of long-term standardized group lifestyle intervention on BP and MCI of the hypertensive occupational workers remains poorly researched. One of the occupational groups (i.e., at particular risk of hypertension) is mine workers. This is related to their hard working environment and work environment-related lifestyle. However, the effectiveness of comprehensive strategies for preventing and treating high BP in mine workers has not been tested. According to the Chinese guidelines on hypertension treatment, the nonpharmacological treatment of hypertension (lifestyle intervention) included: reduce sodium intake (World Health Organization [WHO] recommended <6 g daily), increase potassium intake, weight control, quit smoking, restrict alcohol consumption, physical exercise, reduce mental stress, and maintain a psychological balance.[9]

This is the first prospective cohort study to investigate effects of long-term lifestyle intervention on cognitive function in hypertensive personnel in mining areas of China. In the 2-year-follow-up, we will measure the effect of long-term standardized group lifestyle intervention on their BP and cognitive function, and compare the results with a control group that receive no intervention, to explore whether lifestyle interventions can effectively improve the cognitive function of hypertensive workers in mined areas by improving BP.

2. Methods

2.1. Study design

Between September 2013 and December 2015, in the China Shaanxi Province, 510 participants were recruited by general practitioners during a routine health check-up. The study was approved by the First Affiliated Hospital of Xi'an Jiaotong University (approval No. KYLLSL2014-135-01, approval date, August 25, 2014), and signed agreements with the local staff hospitals, and was conducted according to the tenets of the Declaration of Helsinki and its revisions. The study was a double-blind test. All participants gave written informed consent to participate in the study.[10]

The initial study cohort consisted of professionals working in a relatively closed mining area: Mine workers were chosen for the current study because it would have a minimal staff turnover during the 2-year testing period, and it was subjected to regular annual medical examinations at the local hospital. These participants would thus be less likely than other working populations to withdraw from the study. The 2 mines were 180 km apart, so the nonintervention mining staff were unlikely to hear about the interventions received by the intervention group.[10]

During the 2-year follow-up, in the intervention group, the doctors provided health education and behavior counseling monthly and urged the hypertensive participants to improve their lifestyle. All participants in the intervention group also received regular health seminars and free health education materials about how to prevent and treat hypertension every 3 months (pamphlets were made available in the reception of the main mining office building). Moreover, participants received monthly SMSs and phone calls urging them to improve their lifestyle. In addition, regular sports events (basketball, badminton, table tennis, and mountain climbing) were organized and the participants were invited to join in (sports activities were held every Thursday afternoon, the time for each physical activity was from 16:00 to 18:00, and the staff participated in turns, if they could not attend this time, they could join the next time). The participation rate of research participants is about 90%. The information about lifestyle intervention on hypertension was monthly disseminated. In this study, we recommend the patients of lifestyle intervention group eat like the DASH diet, which emphasizes fruits, vegetables, and low-fat dairy foods. It includes whole grains, poultry, fish, and nuts, and contains smaller amounts of red meat, sweets, and sugar-containing beverages than the typical diet in the United States.[11] First, reduce sodium intake, each person should consume no more than 6 g of salt per day (pickles contain high levels of salt and one should therefore not eat too many pickles, and one should drink plenty of water after eating). Increase the vegetables and fruit intake. Each person should eat 300 to 500 g of vegetables and 200 to 400 g of fruit per day. Second, weight control, the most effective weight loss measures include control energy intake and increase physical activity. Each person should determine their optimal threshold of daily fat consumption (g) using the following formula: kg of body weight $\times$ 0.45 (we helped them count the specific intake). Fat consumption (such as fat, egg yolks, cakes, and French fries) should not exceed this threshold. Third, quit smoking, strongly recommend and urge patients to quit smoking, and follow up and supervise the successful smokers to avoid relapse. Fourth, restrict drinking, daily alcohol intake should not exceed 25 g for men, and women should not exceed 15 g. White wine, wine, and beer were <50, 100, and 300 mL. Fifth, physical exercise, it is recommended that they should take appropriate physical exercise for about 30 minutes a day and have aerobic exercise more than once a week, such as walking, jogging, cycling, swimming, aerobics, dancing, and so on. And sixth reduce mental stress and maintain a psychological balance,[9,12–13] therapists are general practitioners of local hospitals trained by cardiologists.

All hypertensive participants were followed up for 2 years by visiting to the local general hospital at 6 months, 1 year, and 2 years after the initiation of the study. At all visits, the BP and Montreal Cognitive Assessment (MoCA) questionnaire were measured. The arterial stiffness was measured at the beginning and end of the study. The intervention group was also followed up by monthly telephone calls concerning their BP and lifestyle. Enrollment and the follow-up flow chart are shown in Fig. 1.[10]

2.2. Criteria for eligibility

Participants were included in the study if they had hypertension, and had consistently participated in the annual health examination, and were the mining staff (managers, clerks, and mine workers). Hypertension was diagnosed according to the 2010 Chinese Hypertension Prevention guidelines, namely, the SBP of ≥140 mm Hg or the DBP of ≥90 mm Hg, or taking antihypertensive drugs 2 weeks before the start of the study.[14]

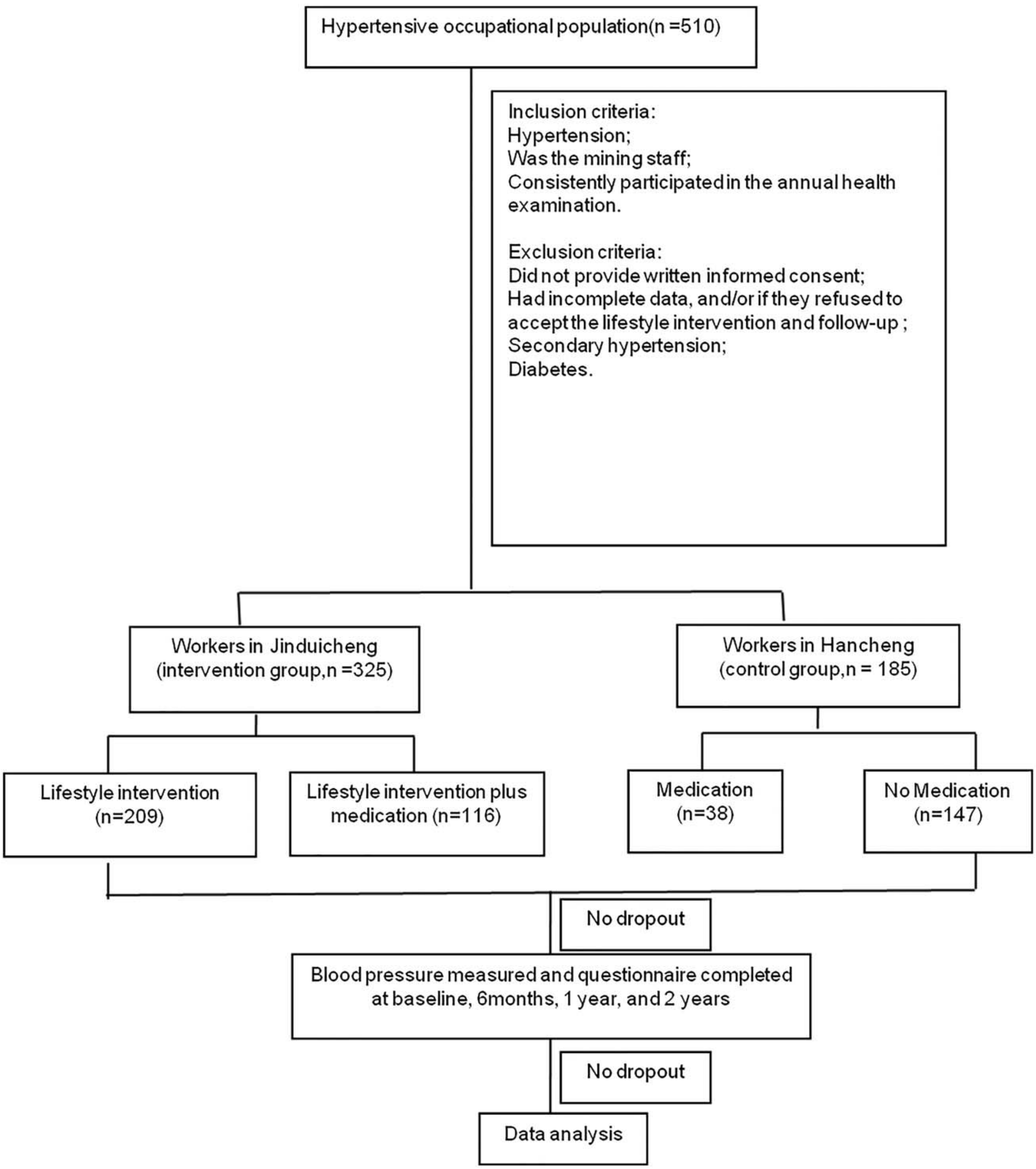

Figure 1. Enrollment flow chart.

Eligible subjects were excluded if they did not provide written informed consent, had incomplete data, and/or if they refused to accept the lifestyle intervention and follow-up, and they were secondary hypertension or diabetes. Following this standard exclusion, after screening, the intervention group comprised 325 subjects and the control group comprised 185 subjects.

2.3. Assessments

2.3.1. *Physical examination.* BP was measured using a standard mercury sphygmomanometer. The subjects were asked to rest for 5 minutes in the sitting position, after which the BP in their right upper limb was measured twice at least 1 minute apart. SBP and DBP were recorded as phase I and V Korotkoff sounds. If the difference between the 2 measurements exceeded 5 mm Hg (1 mm Hg = 0.133 kPa), the BP was measured again. The average BP was then recorded.[10]

2.3.2. *BaPWV and ABI measurement and evaluation standard.* We used Omron Automatic Atherosclerosis Tester (ST-203ATIII-230V), and the room temperature maintained at around 25°C. A pressure-sensitive probe was placed at the most obvious pulsation of the radial artery and radial artery. The electrode was connected and the arterial pulse waveform was traced for 5 minutes. The instrument automatically analyzed the results and output. The ba-PWV was taken as the higher value in the bilateral limb measurement, and the ankle-brachial index (ABI) was taken as the lower value in the bilateral. Criterion: When the brachial-ankle pulse wave velocity (baPWV) <1400 cm/s, the peripheral arterial elasticity is defined as normal; when baPWV is higher than 1400 cm/s, peripheral arteriosclerosis is considered. ABI ≤ 0.90 is the standard cut-off for the diagnosis of peripheral arterial disease (i.e., there may be occlusion of lower extremity arteriosclerosis).

2.3.3. *Montreal Cognitive Assessment.* The MoCA is a rapid screening instrument to identify MCI.[15] It assesses attention and concentration, executive functions, memory, language, visuo-constructional skills, conceptual thinking, calculations, and orientation. The total possible scores are 30 points, and a score of ≥26 is considered normal. To counterbalance the effect of lower education, 1 point was added to the final score of those individuals with <12 years of education. A previous validation study in China suggested 26 points as the ideal cutoff for MCI identification. Under the recommended cut-off score of 26, the MoCA demonstrated an excellent sensitivity of 90.4% and a fair specificity of 31.3%.[16] These indicate that with optimal cutoffs, the MoCA is valid to screen for cognitive impairment.

Outcomes in the intervention and control groups were assessed in terms of mean improvement in BP and MoCA at 6 months, 1 year, and 2 years compared with baseline. All hypertensive patients from both groups were asked to do the MoCA questionnaire.[10] They were divided into hypertension stage 1 to 3 subgroups according to the BP level. According to the United Nations WHO proposed the new age segment, under 44 years old are young people and 45 to 59 years old are middle-aged people. Therefore, according to their age, they were divided into under 45 and 45 to 60 subgroups, each subgroup was assessed for changes in MoCA scores. Some hypertensive patients were not taking medications for economic or other reasons. To rule out the effect of drugs on BP and cognitive function, hypertensive patients in the 2 groups were divided into 2 subgroups: medication and no medication. We then analyzed changes in BP, total cholesterol (TC), blood glucose (Glu), and MoCA scores in the 4 subgroups.

2.4. Statistical analyses

Data were entered in a double-entry fashion using Epidata 3.1 software, which is a data entry software, and double-entry fashion can improve the accuracy of input. Continuous variables were expressed as the mean ± standard deviation. Categorical data were expressed as number (%). Repeated measures ANOVA was used to assess BP and MoCA scores, including the factors "group" (intervention/control), "time period" (at baseline, 6 months, 1 year, and 2 years). Between-group comparison of continuous variables was made using 1-way analysis of variance followed by the Student–Newman–Keuls method. Between-group comparisons of categorical variables were made using the chi-squared test. The 2010 national 6th census data were used to standardize the data according to age. All data were analyzed using SPSS 19.0 software. *P* values on 2-sided tests that exceeded .05 were considered to be statistically significant.[10]

3. Results

3.1. Baseline characteristics of the whole cohort

As shown in Table 1, a total of 510 hypertensive patients were included in the study, males accounted for 74.9% and women accounted for 25.1%, and the average age was 45.6 ± 13.4 years old. The average SBP was 153.4 ± 12.5 mm Hg, and the average DBP was 98.3 ± 11.6 mm Hg. There was no significant difference in gender, age, educational level, occupation, SBP, DBP, body mass index, or Glu, TC, the percentage of smoking and the use of drugs at baseline between intervention group and control group (*P* > .05).

Table 1

Baseline characteristics of the whole cohort and patients with hypertension in the intervention and control groups.

Variables	Total (n = 510)	Hypertensive control group (n = 185)	Hypertensive intervention group (n = 325)	P^*
Sex (male), n (%)	382 (74.9)	139 (75.2)	243 (74.8)	.138
Age (mean ± SD), y	45.6 ± 13.4	44.8 ± 14.2	45.2 ± 13.8	.067
BMI (mean ± SD), kg/m^2	23. 4 ± 1.9	23.1 ± 1.4	23.6 ± 1.4	.053
Education (mean ± SD), y	10.6 ± 1.8	11.1 ± 1.4	10.8 ± 1.5	.284
SBP (mean ± SD), mm Hg	153.4 ± 12.5	153.6 ± 11.7	153.2 ± 11.6	.515
DBP (mean ± SD), mm Hg	98.3 ± 11.6	98.4 ± 12.5	99.3 ± 10.4	.691
Blood glucose, mmol/L	4.6 ± 1.1	4.8 ± 1.2	4.5 ± 1.1	.386
Total cholesterol, mmol/L	4.2 ± 1.3	4.1 ± 1.2	4.3 ± 1.7	.403
Smoking, n (%)	267 (52.4)	99 (53.5)	168 (51.7)	.269
MCI (%)	107 (21.0)	38 (20.5)	69 (21.2)	.462
Antihypertensive drugs				
ARB, n (%)	33 (6.5)	11 (5.9)	22 (6.8)	.318
ACEI, n (%)	30 (5.9)	10 (5.4)	20 (6.2)	.094
Diuretics, n (%)	36 (7.1)	12 (6.5)	24 (7.4)	.136
CCB, n (%)	50 (9.8)	17 (9.2)	33 (10.2)	.065
BB, n (%)	25 (4.9)	8 (4.3)	17 (5.2)	.273

All data are given as the mean ± standard deviation or n (%), as appropriate.

ACEI = angiotensin-converting enzyme inhibitors, ARB = angiotensin II receptor blockers, BB = beta blockers, BMI = body mass index, CCB = calcium-channel blockers, DBP = diastolic blood pressure, MCI = mild cognitive impairment, SBP = systolic blood pressure, SD = standard deviation.

* The control and intervention groups did not differ significantly in terms of the listed characteristics (all *P* > .05), as determined by 1-way analysis of variance followed by the Student–Newman–Keuls method or the chi-squared test.

3.2. Cognitive function according to BP level at baseline

As shown in Table 2, the higher the BP, the lower the MoCA scores ($P<.05$). There was no significant difference between 2 groups at the 3 stages ($P>.05$).

3.3. Cognitive performance according to age at baseline

To exclude the influence of age on cognitive function, we compared the hypertensive patients whose age was between 45 and 59 to those under 45, and we found that there was no obvious difference between 2 subgroups in both control and intervention groups ($P>.05$). Results are presented in Table 3.

3.4. Effect of long-term lifestyle intervention on BP, TC, Glu, and cognitive function of patients with hypertension

One hundred sixteen hypertensive patients of the intervention group received antihypertensive drugs and 209 hypertensive patients did not take medication. Thirty-eight hypertensive patients of the control group took antihypertensive drugs. After 2 years, the BP, TC, Glu, and baPWV of the Lifestyle intervention subgroup and Lifestyle intervention plus medication subgroup decreased, and the MoCA scores and ABI increased ($P<.05$). However, in the No lifestyle intervention nor medication subgroup, the BP and baPWV increased and the MoCA scores decreased ($P<.05$). Compared with the Lifestyle intervention subgroup, the BP, TC, Glu, and baPWV of Lifestyle intervention plus medication subgroup were lower, and the MoCA scores and ABI were higher, although there is no statistical difference. Compared with the No lifestyle intervention nor medication subgroup, the BP, TC, Glu, and baPWV of the Lifestyle intervention subgroup were lower and the MoCA scores and ABI were higher ($P<.05$). Results are presented in Table 4.

The BP and MoCA scores at baseline, 6 months, 1 year, and 2 years were analyzed in patients with hypertension in the intervention and control groups. There was no significant between-group difference in BP or MoCA at baseline or at 6 months ($P>.05$). Compared with baseline, in the Lifestyle intervention subgroup, Medication subgroup, and Lifestyle intervention plus medication subgroup, the BP decreased and MoCA scores increased significantly ($P<.05$) after 1 year of intervention. At 2 years, this difference was even more significant ($P<.05$). However, the BP and MoCA scores of No lifestyle intervention nor medication subgroup had no obvious change ($P>.05$). The results are presented in Fig. 2.

4. Discussion

As people's living standards improve and lifestyle changes, the incidence of hypertension increases year by year. Workers in mining areas is a special occupational group, they are less concerned about their BP. Previous studies have shown that the incidence of hypertension among mineral professionals is significantly higher than the general population.[17,18] There was no significant difference in baseline between the 2 groups of participants. It is suggested that the 2 groups of patients are comparable, so we can conduct the next study.

Excessive salt intake, smoking, obesity, and lack of exercises are well-known risk factors of hypertension. The influence of lifestyle on hypertension is unclear. Many studies show that hypertension is related to MCI.[19] In our study, we divide BP into 3 levels. We found that with the increase of BP level, the MoCA scores decreased significantly, and there was no obvious difference between 2 groups at the 3 stages. This is consistent with previous studies and shows that elevated BP may affect cognitive function through arterial stiffness, which affects cerebrovascular perfusion.[20–22] We suggest that hypertension increases the occurrence of cognitive dysfunction. Therefore, our results indicate that attention should be paid to the relationship between hypertension and cognitive function. And we should take active intervention to reduce the incidence of hypertension in occupational groups.

The definition of the intermediate stage of cognitive dysfunction is difficult, and MCI is currently a recognized transitional stage between degenerative cognitive impairment and dementia, and plays an important role in the discovery of cognitive function changes.[23–26] The MoCA is a brief cognitive screening tool with high sensitivity and specificity for detecting MCI.[15] This is the first study to evaluate the cognitive function of hypertensive patients through MoCA in mining areas of China.

Table 2

Cognitive performance according to blood pressure level.

	Control group			Intervention group		
	HTN-1 (n=67)	HTN-2 (n=86)	HTN-3 (n=32)	HTN-1 (n=87)	HTN-2 (n=179)	HTN-3 (n=59)
MoCA	28.16±1.54	26.93±2.83*	25.36±3.60†	27.91±1.73	26.84±2.61*	25.25±2.17†

ANOVA = analysis of variance, HTN = hypertension, MoCA = Montreal Cognitive Assessment.
All data are given as the mean±standard deviation.
* The significance of change in MoCA scores at HTN-2 relative to HTN-1 was assessed using 1-way ANOVA.
† The significance of change in MoCA scores at HTN-3 relative to HTN-2 was assessed using 1-way ANOVA.

Table 3

Cognitive performance according to age.

Age, y	Control group			Intervention group		
	<45 (n=89)	45–59 (n=96)	P*	<45 (n=169)	45–59 (n=156)	P*
MoCA	28.16±1.54	27.84±1.47	.62	27.69±1.64	27.25±1.34	.47

All data are given as the mean±standard deviation.
ANOVA = analysis of variance, MoCA = Montreal Cognitive Assessment.
* The significance of change in MoCA scores at <45 years old relative to 45 to 59 years old was assessed using 1-way ANOVAs.

Table 4

The influence of lifestyle intervention on blood pressure, TC, Glu, and MCI in patients with hypertension.

	Lifestyle intervention (n=209)				Lifestyle intervention plus medication (n=116)				Medication (n=38)				No lifestyle intervention nor medication (n=147)						
	Baseline	2 y	|Δ|[‖]	P^*	Baseline	2 y	|Δ|[‖]	P^*	Baseline	2 y	|Δ|[‖]	P^*	Baseline	2 y	|Δ|[‖]	P^*	$\Delta P_0^\dagger$	$\Delta P_1^\ddagger$	$\Delta P_2^\S$
SBP, mm Hg	155.2±10.3	147.6±8.6	7.6±1.5	.01	156.4±11.5	140.1±12.5	16.3±2.8	.001	157.4±10.7	145.8±8.9	11.6±2.9	.001	156.7±12.1	162.3±10.8	6.6±2.9	.01	0.001	0.02	0.001
DBP, mm Hg	104.4±6.3	98.1±6.4	6.3±1.1	.34	105.8±8.9	93.2±11.6	12.6±1.7	.001	105.6±5.6	96.3±7.8	9.3±1.4	.001	106.9±7.3	111.5±9.3	4.6±1.4	.01	0.001	0.01	0.001
TC, mmol/L	4.9±0.8	3.8±0.6	1.1±0.02	.03	4.8±0.6	3.5±0.6	1.3±0.02	.03	4.9±0.6	4.8±0.5	0. 1±0.02	.34	4.8±0.7	4.9±0.6	0.1±0.02	.38	0.14	0.01	0.01
Glu, mmol/L	4.8±0.5	3.6±0.6	1.2±0.03	.21	4.7±0.4	3.4±0.9	1.3±0.03	.02	4.8±0.5	4.6±0.6	0.2±0.03	.21	4.8±0.8	5.0±0.7	0.2±0.03	.42	0.59	0.01	0.01
MoCA	27.2±1.8	28.9±1.7	1.7±0.3	.04	26.9±1.4	29.4±1.3	2.5±0.6	.001	27.3±1.5	28.7±1.7	1.4±0.1	.03	27.5±1.4	26.1±1.5	1.4±0.1	.03	0.43	0.001	0.01
ABI	1.03±0.12	1.17±0.11	0.14±0.01	.03	1.02±0.11	1.26±0.03	0.24±0.03	.01	1.04±0.12	1.21±0.03	0.20±0.01	.02	1.03±0.13	1.02±0.12	0.01±0.002	.57	0.15	0.25	0.03
baPWV, m/s	1328±104.8	1106±75.2	222±26.1	.04	1369±126.1	1028±63.2	341±29.3	.01	1338±130.4	1057±42.6	281±19.5	.02	1326±109.2	1381±137.9	55±31.4	.31	0.24	0.63	0.02

All data are given as the mean±standard deviation.

ABI=ankle-brachial index, baPWV=brachial-ankle pulse wave velocity, DBP=diastolic blood pressure, Glu=blood glucose, MCI = mild cognitive impairment, MoCA=Montreal Cognitive Assessment, SBP=systolic blood pressure, TC=total cholesterol.

* The significance of change in systolic and diastolic blood pressures, TC, glucose, MoCA scores, ABI, and baPWV at 2 years relative to baseline was assessed using 1-way ANOVA.

† Differences in systolic and diastolic blood pressures, TC, glucose, and MoCA scores (blood pressure, TC, glucose, MoCA scores, ABI, and baPWV at 2 years − blood pressure, TC, glucose, and MoCA at baseline) in the "Lifestyle intervention" subgroup relative to the "Lifestyle intervention plus medication" subgroup was assessed using 1-way ANOVA.

‡ Differences in systolic and diastolic blood pressures, TC, glucose, and MoCA (blood pressure, TC, glucose, MoCA scores, ABI, and baPWV at 2 years − blood pressure, TC, glucose, and MoCA at baseline)in the "Medication" subgroup relative to the "Lifestyle intervention plus medication" subgroup was assessed using 1-way ANOVA.

§ Differences in systolic and diastolic blood pressures, TC, glucose, and MoCA (blood pressure, TC, glucose, MoCA scores, ABI, and baPWV at 2 years − blood pressure, TC, glucose, and MoCA at baseline) in the "Lifestyle intervention" subgroup relative to the "No lifestyle intervention nor medication" subgroup was assessed using 1-way ANOVA.

‖ Differences in systolic or diastolic blood pressures, TC, glucose, and MoCA between 2 years and baseline.

Age is closely related to cognitive function, to exclude the influence of age on cognitive function, we compared the hypertensive patients whose age was between 45 and 59 to those under 45, and we found that there was no obvious difference between 2 subgroups in both control and intervention groups. Thus, we can focus the effect of lifestyle intervention on cognitive function. We suggest that hypertensive middle-aged patients should be routinely tested for cognitive dysfunction because it may be an early predictor of dementia and antihypertensive treatment could slow cognitive decline in these patients.[27]

Lifestyle intervention can improve diabetes and cardiovascular diseases.[28,29] Antihypertensive drugs can decrease BP and then affect cognitive function. In this study, participants used the angiotensin II receptor blockers, angiotensin-converting enzyme inhibitors, diuretics, calcium-channel blockers, and beta blockers to control the BP, and there was no significant difference between the 2 groups in the percentage of the above drug use. In order to rule out the effects of antihypertensive drugs, this study divided the 2 groups of patients into Lifestyle intervention, Lifestyle intervention plus medication, Medication, and No lifestyle intervention nor medication subgroups based on whether patients were taking medication or not. This study showed that lifestyle intervention improved BP, TC, Glu, arterial stiffness, and cognitive function, and this effect was enhanced when implemented in conjunction with antihypertensive drugs.

There are several possible explanations for this finding. First, lifestyle intervention can decrease the intake of salt and fat, and increase the physical exercise, which can reduce the body weight. Studies have shown that body weight is closely related to the BP level.[30] Second, the BP level is related to the blood perfusion of brain and the arterial stiffness, which lead to the imbalance in auto-regulation of cerebral blood flow and cerebral vascular alterations, and then lead to the MCI. Lifestyle intervention decreased the BP level, and increased the blood perfusion of brain, and finally improved the cognitive function. Third, lifestyle intervention reduced the Glu and TC, which in turn reduces their damage to the brain's blood vessels. Higher level of Glu and blood lipids can lead to the microvascular injury and atherosclerosis of the cerebrovascular, which may reduce the blood perfusion and damage of the brain and then lead to the cognitive dysfunction. To conclude, lifestyle intervention (alongside antihypertensive drugs) as a treatment for primary hypertension can be considered as an important auxiliary measure to improve the cognitive function.

Few previous studies have investigated the long- and short-term effects of lifestyle interventions on disease.[31] Our study reveals a difference in both the long- and short-term effects of lifestyle intervention on BP and MCI in patients with hypertension. There was no significant difference in BP or MoCA scores between the No lifestyle intervention nor medication, Lifestyle intervention, Lifestyle intervention plus medication, and Medication subgroups at 6 months. However, at 1 year, the BP and MoCA scores of the Lifestyle intervention, Lifestyle intervention plus medication, and Medication subgroups were better than those of the No lifestyle intervention nor medication subgroup. At 2 years, these differences were even more significant. These results suggest that long-term lifestyle intervention is helpful for improving BP and cognitive function in hypertensive patients. Hypertensive patients need not only long-term drug treatment, but also long-term lifestyle intervention.

Previous studies on MCI in hypertensive patients have focused on the influencing factors of MCI[31] or the relationship between

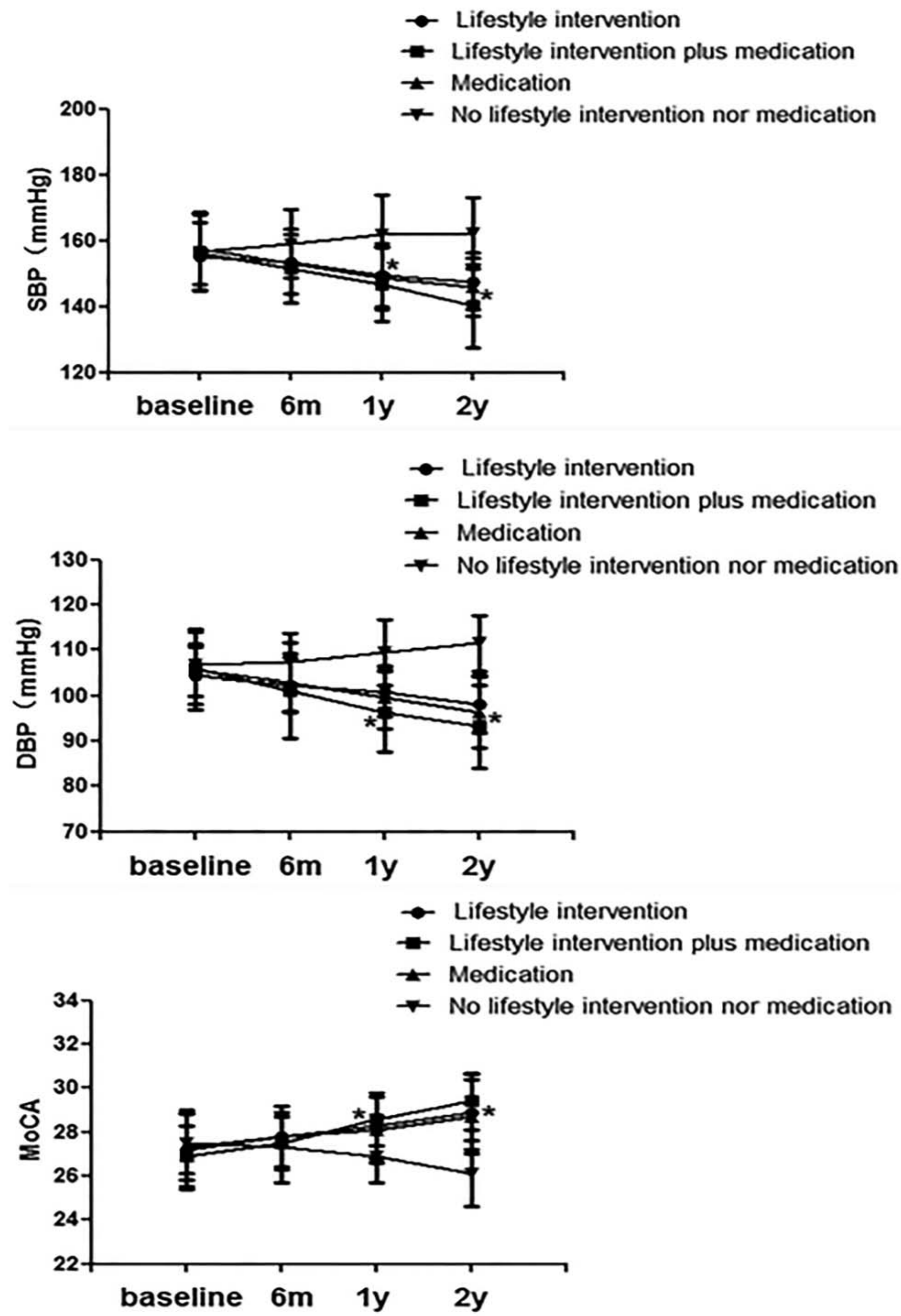

Figure 2. Effects of long-term lifestyle intervention on blood pressure and MoCA scores of patients with hypertension. *Significant change ($P < .05$) in blood pressure and MoCA scores at the indicated time point relative to baseline, as assessed by the Student–Newman–Keuls method. MoCA = Montreal Cognitive Assessment.

hypertension and MCI.[32] However, this is the first study to investigate the effects of lifestyle intervention on cognitive function in hypertensive occupational patients in China. The results show that lifestyle intervention can significantly improve the cognitive function of patients with hypertension. Lifestyle intervention may become one nondrug therapy that can stable BP and reduce adverse health effects, ultimately improving the cognitive function of patients.

This study has several limitations. First, MCI is a cognitive state between the normal aging and dementia, this study mainly based on MoCA scores to evaluate the cognitive function of hypertensive patients. Second, the effects of drugs cannot be completely ruled out. Due to economic or other reasons, not all hypertensive patients take medications. Despite the separate analysis of drug factors (Table 4 and Fig. 2), we still cannot rule out the impact of drugs on BP. Third, cognitive function is related to age, and the participants were 45.6 ± 13.4 years old; therefore, the findings may not apply to older individuals.

The highlights and significance of this study: First, the research object is middle-aged mining staff with special working environment, and we have the control group who had a similar geographical location and similar living and working conditions with the intervention group. Second, previous studies have just compared the baseline and postintervention differences, and have not compared the long- and short-term interventions. We found that the effect of long-term standardized group lifestyle intervention on BP and cognitive function of hypertensive occupational population is better. Third, we suggest that long-term lifestyle intervention may improve the cognitive function through improving the BP, blood lipids, and Glu.

In this cohort study of 510 adults with hypertension, we examined BP, TC, Glu, and MoCA questionnaire over a period of 2 years. Our results show that long-term lifestyle intervention can improve the cognitive function of patients with hypertension. Lifestyle intervention alone can effectively improve BP, TC, Glu, and cognitive function, when implemented in conjunction with drug treatment for hypertension, greater improvements were seen in BP and MoCA scores.

In conclusion, we suggest that lifestyle intervention may improve the cognitive function through reducing the BP, Glu, and blood lipids. The long-term standardized group lifestyle intervention can be used as adjunctive therapy to improve the BP and cognitive function of hypertensive occupational population in China.

Author contributions

Data curation: Min Li, Lei Liu.
Formal analysis: Min Li, Lei Liu.
Funding acquisition: Zengwu Wang, Gang Tian.
Investigation: Min Li, Lei Liu, Shaowu Song, Anshi Shi, Yunlong Ma, Songlin Zhang, Zengwu Wang, Danjun Zhu, Gang Tian.
Methodology: Zengwu Wang, Gang Tian.
Project administration: Zengwu Wang, Gang Tian.
Resources: Shaowu Song, Anshi Shi, Gang Tian.
Supervision: Zengwu Wang, Gang Tian.
Writing – original draft: Min Li, Lei Liu, Gang Tian.
Writing – review and editing: Min Li, Lei Liu ,Gang Tian.

References

[1] Weiwei Chen , Runlin Gao , Lisheng Liu , et al. The summary of China Cardiovascular Disease Report 2016. Chin J Circ 2017;32:521–30.
[2] Yu RJ, Yan LJL, Wang HL, et al. Effectiveness of a community-based individualized lifestyle intervention among older adults with diabetes and hypertension, Tianjin, China, 2008–2009. Prev Chronic Dis 2014;11: E84.
[3] Hebert LE, Scherr PA, Bienias JL, et al. Alzheimer disease in the U.S. population: prevalence estimates using the 2000 census. JAMA Neurol 2003;60:1119–22.
[4] Kelly A, Calamia M, Koval A, et al. Independent and interactive impacts of hypertension and diabetes mellitus on verbal memory: a coordinated analysis of longitudinal data from England, Sweden, and the United States. Psychol Aging 2016;31:262–73.
[5] Lv YB, Zhu PF, Yin ZX, et al. A U-shaped association between blood pressure and cognitive impairment in Chinese elderly. J Am Med Dir Assoc 2017;18:193.e7–13.
[6] Giovambattista D, Catherine KU, Davide G, et al. Benefits in cognitive function, blood pressure, and insulin resistance through cocoa flavanol consumption in elderly subjects with mild cognitive impairment. Hypertension 2012;60:794–801.
[7] Nagai M, Hoshide S, Ishikawa J, et al. Visit-to-visit blood pressure variations: new independent determinants for cognitive function in the elderly at high risk of cardiovascular disease. J Hypertens 2012;30:1556–63.
[8] Guo R, Wang ZW, Wang X, et al. Current status and influencing factors of hypertension in occupational population in some provinces of China. Chin J Circ 2014;29:172–5.
[9] The updated version of Chinese guidelines on hypertension in 2017.
[10] Liu L, Li M, Tian G, et al. Effect of lifestyle intervention on hypertension in the occupational population of two mining areas in China. Hypertens Res 2017;40:999–1007.
[11] Sacks FM, Svetkey LP, Vollmer WM, et al. Effects on blood pressure of reduced dietary sodium and the Dietary Approaches to Stop Hypertension (DASH) diet. DASH-Sodium Collaborative Research Group. N Engl J Med 2001;344:3–10.
[12] Liu LS. Guidelines for the prevention and treatment of hypertension in China 2010. Chin J Cardiol 2011;39:701–8.
[13] McCullough ML, Willett WC. Evaluating adherence to recommended diets in adults: the alternate healthy eating index. Public Health Nutr 2006;9:152–7.
[14] World Health Organization. Diet, Nutrition and the Prevention of Chronic Diseases: Report of the Joint WHO/FAO Expert Consultation. Geneva: WHO; 2014.
[15] Nasreddine ZS, Phillips NA, Bedirian V, et al. The Montreal Cognitive Assessment, MoCA: a brief screening tool for mild cognitive impairment. J Am Geriatr Soc 2005;53:695–9.
[16] Yu J, Li J, Xin H. The Beijing version of the Montreal cognitive assessment as a brief screening tool for mild cognitive impairment: a community-based study. BMC Psychiatry 2012;12:156.
[17] Sonkodi B, Sonkodi S, Steiner S, et al. High prevalence of prehypertension and hypertension in a working population in Hungary. Am J Hypertens 2012;25:204–8.
[18] Guo R, Wang ZW, Wang X, et al. Hypertension prevalence for working population in several provinces in China. Chin Circ J 2014;35:734–8.
[19] Gao SJ, Jin YL, Frederick W, et al. Hypertension and cognitive decline in rural elderly Chinese. J Am Geriatr Soc 2009;57:1051–7.
[20] Marijana T, Cesare C, Dagmara H. Hypertension and cognitive dysfunction in elderly: blood pressure management for this global burden. BMC Cardiovasc Disord 2016;16:2–9.
[21] Cooper LL, Woodard T, Sigurdsson S, et al. Cerebrovascular damage mediates relations between aortic stiffness and memory. Hypertension 2016;67:176–82.
[22] Tzourio C, Anderson C, Chapman N, et al. Effects of blood pressure lowering with perindopril and indapamide therapy on dementia and cognitive decline in patients with cerebrovascular disease. Arch Intern Med 2003;163:1069–75.
[23] Flicker C, Ferris SH, Reisberg B. Mild cognitive impairment in the elderly: predictors of dementia. Neurology 1991;41:1006–9.
[24] Unverzagt FW, Gao S, Baiyewu O, et al. Prevalence of cognitive impairment: data from the Indianapolis Study of Health and Aging. Neurology 2001;57:1655–62.
[25] Petersen RC, Roberts RO, Knopman DS, et al. Mild cognitive impairment: ten years later. Arch Neurol 2009;66:1447–55.
[26] Stephan BC, Savva GM, Brayne C, et al. Optimizing mild cognitive impairment for discriminating dementia risk in the general older population. Am J Geriatr Psychiatry 2010;18:662–73.
[27] Forette F, Seux ML, Staessen JA, et al. The prevention of dementia with antihypertensive treatment: new evidence from the systolic hypertension in Europe (Syst-Eur) study. Arch Intern Med 2002;162: 2046–52.
[28] Hamdy O, Mottalib A, Morsi A, et al. Long-term effect of intensive lifestyle intervention on cardiovascular risk factors in patients with diabetes in real-world clinical practice: a 5-year longitudinal study. BMJ Open 2015;5:1–1.
[29] Wang W, Ma L, Sui H, et al. The effect of intensive lifestyle intervention on blood pressure in patients with hypertension, sub-analysis from CHIEF. J Hypertens 2016;34(suppl 1):e77.
[30] Williams PT. Increases in weight and body size increase the odds for hypertension during 7 years of follow-up. Obesity (Silver Spring) 2008;16:2541–8.
[31] Muela HC, Costa-Hong VA, Yassuda MS, et al. Hypertension severity is associated with impaired cognitive performance. J Am Heart Assoc 2017;6:e004579.
[32] Qiu CX, Winblad B, Fratiglioni L. The age-dependent relation of blood pressure to cognitive function and dementia. Lancet Neurol 2005; 4:487–99.