Mobility speed predicts new-onset hypertension: a longitudinal study

Yaoxin Chen[a,b], Yuewen Liu[a]*, PeiPei Han[a], Hui Zhang[b], Yan Mei[a], Yiwen Wang[a], Jiayou Wang[a], Jinxuan Zhao[a], Rui Sha[a], Wei Wang[a], Qi Guo[a] and Hong Wang[a]

Objective The aim of this study was to investigate whether declining mobility and muscle strength predict new-onset hypertension in suburban-dwelling elderly individuals.

Methods This study was designed as a longitudinal prospective cohort study. It was comprised of 362 individuals (mean age=67.8±6.2; 157 men) without hypertension at baseline. At baseline, all participants completed health questionnaires and underwent measurements of mobility [the Timed Up and Go test (TUGT) and 4-m walking test] and muscle strength (grip strength). At 1-year follow-up, we determined the number of participants who had developed new-onset hypertension. We then evaluated the relationship between above metrics and the development of hypertension.

Results In the present study, 94 (26.0%) participants developed hypertension after 1 year. After adjusting for mixed factors, the TUGT scores [hazard ratio=1.15; 95% confidence interval (CI), 1.10–1.31; *P*=0.030] were positively associated with the development of hypertension, while the 4-m walking test scores (hazard ratio=0.07; 95% CI, 0.01–0.47; *P*=0.007) showed an inverse relationship with hypertension incidence. Grip strength (hazard ratio=1.03; 95% CI, 0.99–1.06; *P*=0.098) was not significantly associated with hypertension incidence.

Conclusion Our results indicate that people with declining mobility are significantly more likely to develop hypertension. Hence, improving mobility could be protective against hypertension for elderly individuals. *Blood Press Monit* 27: 22–26 Copyright © 2021 The Author(s). Published by Wolters Kluwer Health, Inc.

Introduction

An estimated more than 60% adults over 60 years of age has hypertension [1], contributing to 50% of cardiovascular disease-related deaths [2]. Needless to say hypertension places a great burden on society and the economy. As the population ages, the prevalence of hypertension will increase even more [3] unless effective preventive measures for risk factors are implemented in normotensives.

On the basis of previously published longitudinal studies, it has been published that physical activity is causally related to hypertension [4]. The underlying mechanism involved in the association between physical activity and hypertension is still not explicit. There are two possible factors for this connection more directly, that is, muscle strength and mobility. They are two essential conditions for maintaining daily physical activity level [5], and their measurements are more objective and convenient relative to the way of physical activity. Epidemiological study has linked muscle strength as a predictor to impaired mobility [6]. Mobility impairments are likely to be the other risk factors for hypertension that has been recommended as an additional 'vital sign' [7]. Some studies have focused on the correlation between mobility [8,9]/ muscle strength [10,11] and hypertension, but there is no longitudinal study using both of them as predictive indicators for considering their interaction.

In China, hypertension is even more prevalent in rural areas compared to urban areas, and the rate of poorly controlled hypertension is also higher in rural areas [12,13]. Therefore, the purpose of this study was to assess the relationship between hypertension and the above parameters among suburban-dwelling elderly Chinese individuals in order to identify individuals at high risk for hypertension before it happened, so that these individuals could

promptly receive preventive interventions, possibly including physical rehabilitation.

Methods

This study was approved by ethics committee of Tianjin Medical University, and the methods were carried out in accordance with the principles of the Declaration of Helsinki. Informed consent was obtained from all subjects.

Participants

From July 2015 to July 2016 at follow-up, subjects were recruited from the pool of 813 subjects that had participated in the National Free Physical Examination Program in the Hangu Health Center of Tianjin, China. For the purposes of the present study, subjects ≥60 years of age were invited to participate in a comprehensive geriatric assessment twice by the same group of researchers in July 2015 and July 2016. People without hypertension diagnosis at baseline were included in the analysis. The exclusion criteria were as follows: (1) history of diagnosis hypertension, (2) unable to provide informed consent, (3) inability to complete study tasks (i.e. physical disability, incomprehension, or unwillingness to comply with instructions), and (4) having a diagnosis that could affect muscle strength or mobility (i.e. amyosthenia, Parkinson disease).

Baseline variables

All patients completed health questionnaires, had their height, weight, and blood pressure (BP) taken, and underwent measurements of physical performance. The questionnaires included questions about age, sex, occupation, educational level, marital status, smoking habits, drinking habits, history of illness (i.e. diabetes, hyperlipidemia, heart disease, peptic ulcer disease, stroke, osteoarthritis, cancer, kidney disease, hepatic disease, biliary tract disease, thyroid disease, amyosthenia, Parkinson disease, and anemia), and physical activity. Physical activity was assessed using the short form of the International Physical Activity Questionnaire (IPAQ), which asks participants the total minutes spent on vigorous activity, moderate-intensity activity, and walking over the previous 7 days. Total minutes for each activity intensity level were multiplied by 8.0, 4.0, and 3.3, respectively, to yield activity intensity subscores. These subscores were then added up for each participant to generate a total physical activity score.

Height and weight were recorded using a standard protocol. BMI was calculated as weight in kilograms divided by height in meters squared.

Hypertension definition

Participants were considered to be hypertensive if they reported being diagnosed by a clinician or reported taking antihypertensive medications. Office BP evaluation involved two SBP and DBP measurements, using the average of the two measurements, with a validated OMRON model PASESA AVE-2000 (Shisei Datum, Tokyo, Japan). If the individuals without history of hypertension had a measured average SBP ≥140 mmHg or DBP ≥90 mmHg, they would be advised to check with a physician within two weeks. Subsequently, this population was re-examined by professional physician according to the seventh report of the Joint National Committee (the average BPs of two or more measurements taken on different days results in a SBP ≥140 mmHg or DBP ≥90 mmHg) [14].

Mobility

Self-pace mobility was assessed using the 4-m walk test at usual speed. To perform the 4-m walk tests, a 4-m path was marked with red tape. The first and last meters were added to the path to allow for the inevitable acceleration of walking at the beginning of the test and the inevitable deceleration of walking at the end of the test to ensure the walking speed in the intervening 4 m was not confounded by acceleration and deceleration. The time was recorded by stopwatch when the participants were verbally instructed to walk at their usual pace through the 4-m path. The participants were allowed to use a gait-assistance device. Participants completed the task twice. The average time of the two trials was used to compute walking speed.

The Timed Up and Go test (TUGT) is an indicator of mobility at a fast-paced walking speed. It measures the number of seconds needed for an individual to stand up from a chair, walk 3 m as fast as possible past a red cone on the floor, turn around, walk back to the chair, and sit down again with his/her back against the chair. The task was demonstrated before participants were asked to complete it.

Muscle strength

Grip strength was used as a measure of muscle strength and was quantified using a handheld dynamometer (GRIP-D; Takei Ltd, Niigata, Japan). Subjects stood during the task with arms relaxed at their sides unless the participant was physically limited. Participants were asked to exert their maximum effort twice using their dominant hand; the average grip strength was then calculated.

Data analysis

Statistical analysis was conducted using SPSS 19.0 statistical software (SPSS Inc, Chicago, Illinois, USA). Normally distributed continuous variables were expressed as mean ± SD, except for IPAQ variables, which were expressed as medians with 25−75th percentages; classification variables were reported as percentages. Comparisons between participants with and without hypertension were conducted using *t*-tests for normally distributed continuous variables, χ^2 tests for categorical

variables, and Kruskal−Wallis rank tests for ranked data. Simple logistic regression analyses were used to examine the independent effect of different physical performance metrics on hypertension; odds ratios and 95% confidence intervals (CIs) were computed. In addition, adjustments for potential confounders, such as age, sex, BMI (model 1), marital status and illiteracy (model 2), and comorbidity status (diabetes, hyperlipidemia, and stroke) (model 3) were performed using multiple logistic regression analyses.

Results

Baseline characteristics

Four hundred twenty-nine (52.8%) of the original 813 participants were excluded at baseline for having hypertension, 19 subjects were lost to follow-up, and 3 subjects had missing data, resulting in a final analytic sample of 362 individuals without hypertension at baseline.

Ninety-four of 362 participants (mean age = 67.8 ± 6.2; 157 men) developed new onset hypertension after 1 year (Table 1). Participants who developed hypertension were more likely to have fewer years of education and be widowed. They also had a higher BMI and higher prevalence

Table 1 Baseline characteristics of study participants according to the presence of hypertension at 1-year follow-up

Characteristic	No hypertension (n=268)	Hypertension n=94	P value
SBP (mmHg)	119.3±12.3	128.9±8.50	<0.001
DBP (mmHg)	69.3±7.60	72.3±8.20	0.014
Sociodemographic			
Age (years)	66.3±5.70	66.5±5.86	0.704
Female (%)	57.1	55.3	0.766
BMI (kg/m^2)	24.0±3.85	25.1±3.53	0.012
Widowed (%)	9.8	23.3	0.021
Living alone (%)	14.1	10.4	0.358
Illiterate (%)	23.7	33.7	0.040
Farming (%)	90.8	90.6	0.950
Drinking (%)			0.354
Never	67.6	61.5	
<7 Days/week	19.5	24.0	
Daily	13.0	14.6	
Smoking (%)			0.274
Never	52.3	50.0	
Former	15.6	10.4	
Current	32.1	39.6	
Physical metrics			
IPAQ (Met/week)	2056 (1315, 6118)	2153 (903, 4158)	0.303
Grip strength (kg)	25.1±9.30	25.7±10.2	0.582
TUGT(S)	8.51±1.99	9.20±2.08	0.004
4-m walking test (m/s)	1.01±0.17	0.94±0.14	<0.001
Diseases (%)			
Diabetes (%)	8.0	16.0	0.025
Hyperlipidemia (%)	24.8	38.0	0.010
Heart disease (%)	21.9	17.3	0.387
Peptic ulcer (%)	5.3	7.8	0.430
Stroke (%)	2.6	10.4	0.008
Osteoarthritis (%)	16.1	7.7	0.067
Cancer (%)	2.1	3.9	0.411
Kidney disease (%)	5.3	1.3	0.140
Hepatic disease (%)	3.7	0.0	0.089
Biliary tract disease (%)	5.3	3.8	0.624
Thyroid disease (%)	2.6	3.9	0.583
Anemia (%)	0.5	0.0	0.523

IPAQ, International Physical Activity Questionnaire; TUGT, Timed Up and Go test.

of diabetes, hyperlipidemia, and stroke. Finally, their performances on the TUGT and 4-m walking tests were worse than those without hypertension. There was no significant difference in muscle strength between those with hypertension and those without.

Risk factors for hypertension incidence

After adjustments for potential confounders in model 3 (i.e. age, sex, BMI, marital status, illiteracy, and comorbidity status), the three physical risk factors for hypertension were summarized below: grip strength (adjusted hazard ratio = 1.03; 95% CI, 0.99−1.06, P = 0.098), TUGT (adjusted hazard ratio = 1.15; 95% CI, 1.10−1.31, P = 0.030), 4-m walking test (adjusted hazard ratio = 0.07; 95% CI, 0.01−0.47, P = 0.007) (Table 2).

Discussion

To our knowledge, this is the first prospective cohort study of suburban-dwelling elderly Chinese individuals aged 60 years and older, to simultaneously include two critical physical metrics to predict hypertension. In our study, the prevalence of hypertension was 52.8% at baseline; after 1 year 26.0% (female = 25.8%, male = 26.8%) of individuals who did not have hypertension at baseline developed new onset hypertension. These findings are consistent with previous research that reported the prevalence of hypertension among rural-dwelling elderly individuals in China to be 51.4%15 and the incidence of hypertension to be 26.9% [16]. We found that participants with worse performance on the TUGT and the 4-m walking test had a higher risk of developing hypertension, whereas grip strength performance did not impact the development of new onset hypertension.

Better 4-m walking test performance is negatively associated with hypertension

In our study, the association between the 4-m walking test and hypertension was significant. People with subnormal walking speeds had a nearly 1.5-fold risk of developing hypertension. Some cross-sectional research [8] that has reported an inverse correlation between walking speed and hypertension. The previous longitudinal study by Dumurgier et al. [17] showed that slower walking speed resulted in a three-fold increased risk of cardiovascular disease death, but not just associated with hypertension. Our study goes even further by finding that decreased walking speed is an independent risk for hypertension in the elderly. The underlying mechanisms of how decreased walking speed predicts hypertension has yet to be explained. The positive association of hypertension with cerebral small vessel disease has been well established [18]. It is possible that slower walking speed results from cerebral small vessel microbleeds and infarcts [19,20], which results in decreased cerebral blood flow to motor areas of cerebral cortex [21].

Table 2 Multiple logistic regression on incidence of hypertension during baseline to 1-year (*n* = 362)

Variable	Unadjusted		Model 1		Model 2		Model 3	
	Hazard ratio (95% CI)	P	Hazard ratio (95% CI)	P	Hazard ratio (95% CI)	P	Hazard ratio (95% CI)	P
Grip strength	1.01 (0.98–1.03)	0.581	1.01 (0.98–1.03)	0.636	1.01 (0.98–1.04)	0.340	1.03 (0.99–1.06)	0.098
TUGT	1.71 (1.05–1.30)	0.005	1.19 (1.07–1.34)	0.002	1.19 (1.07–1.34)	0.005	1.15 (1.10–1.31)	0.030
4-m walking test	0.07 (0.02–0.31)	0.001	0.06 (0.01–0.29)	<0.001	0.06 (0.11–0.30)	0.001	0.07 (0.01–0.47)	0.007

Model 1: Age, Sex, BMI; Model 2: Model 1+marital status, and illiteracy; Model 3: Model 2+ comorbidity status (diabetes, hyperlipidemia, and stroke).
IPAQ, International Physical Activity Questionnaire; TUGT, Timed Up and Go test.

Better Timed Up and Go test performance is associated with hypertension

After adjusting for many potential confounding factors, our study found that participants with longer TUGT times had an increased risk of developing hypertension. This finding is in line with a previous cross-sectional study [9] that found a significant association between TUGT performance and hypertension. However, our study reveals that a decline in mobility may precede the development of hypertension. This decline in mobility may be secondary to cerebral small vessel disease which compromises the microstructural integrity of the white matter and consequently negatively impacts the descending cortical spinal cord fibers [22]. The same disease process may also precipitate hypertension after worse mobility has already become evident.

Muscle strength is not associated with hypertension

Declining muscle strength has been associated with cardiovascular disease and the prevalence of hypertension [23] in several studies [10,11]. The mechanism of their association is still uncertain, it can be speculated that greater smooth muscle strength provides better protection for load-bearing elastic lamina and collagen fibers that takes dominant responsibility for BP changes [24]. However, our results showed no association between grip strength and hypertension in the older patients, a finding in line with a cohort study by Maslow *et al.* [25]. There are two possible explanations for these discrepant results. One possibility is that the present study's average baseline BP was lower than that of the PURE study [10], suggesting that strength can only be predictive of hypertension after a certain average BP threshold has been reached. Another explanation is that our 1-year follow-up time was not long enough to show a possible predictive relationship between grip strength and hypertension. Nevertheless, 1 year was a sufficient time for the 4-m walking test and the TUGT to show predictive value, indicating that these two metrics are more sensitive than grip strength. By the way, the predictive mechanism of physical activity on hypertension may not be mediated by the variation of muscle strength.

Comorbidity status may be related to hypertension

Participants with diabetes, hyperlipidemia and stroke at baseline were more likely to develop hypertension. Studies have found that these diseases are often associated with decreased physical performance [26], but their temporal relationship remains unclear. It is possible that these diseases impair physical performance, which in turn leads to decreased physical activity, which itself precipitates the onset of hypertension.

Limitations

This study has several limitations. First, the study may suffer from a selection bias as there were participants who were unable or unwilling to finish the physical performance tests. Second, the follow-up time was short and thus the incidence of hypertension may have been underestimated. As a large country, China has marked regional differences and different populations. The extent of the research was limited to a small part of Chinese populations and no general conclusions can therefore be drawn. Thus, large-scale, multicentered prospective trials are needed to confirm the results of this study in the future. In the next study, we will increase the sample size and the region from which the participants are recruited to reduce error and improve the reliability of our data. Lastly, we hope to conduct future research to identify clinically meaningful cutoff points on physical metrics that can be used to screen elderly individuals for hypertension.

Summary

In conclusion, mobility, but not muscle strength, is independent risk factor for hypertension in suburban-dwelling elderly individuals. This study may have crucial relevance for hypertension screening and prevention.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

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