Interactive Effect of Hypertension and Obesity on Disability among Older People: A Observational Study

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Abstract

Background

Both hypertension and obesity are strongly associated with disability, but these associations are in debate among older people. In this context, our study aimed to examine the interactive effect of hypertension and obesity with disability, especially including the control of blood pressure.

Methods

A cross-sectional study was conducted from August to October 2018 in Shanghai, 8648 community-dwelling individuals with a mean age of 70.39 years. Obesity was measured using the body mass index (BMI) in World Health Organization (WHO) Asia criteria. Hypertension control was defined as treatment with antihypertensive medication and a measured blood pressure of less than 140/90 mm Hg. Disability was measured using the self-reported physical self-maintenance scale (PSMS) and the instrumental activities of daily living (IADL) scale developed by Lawton and Brody. Logistic regression with 95% confidence intervals (CI) was used to explore the interactive effect of hypertension and obesity on disability.

Results

A total of 33.60% of participants reported hypertension control, 6.54% for poor hypertension control, 9.27% for ADL disability, and 32.47% for IADL disability. After adjusting social demographics and chronic conditions, versus without hypertension: in independent analyses, poor hypertension control was a risk factor (OR for ADL disability = 1.47, 95% CI = 1.10–1.96; OR for IADL disability = 1.55, 95% CI = 1.27–1.91); in interactive analyses, poor hypertension control was a risk factor in obese subset (OR for ADL disability = 1.73, 95% CI = 1.09–2.74; OR for IADL disability = 1.80, 95% CI = 1.31–2.47), but a protective factor in underweight subset (OR for ADL disability = 0.33, 95% CI = 0.18–0.62; OR for IADL disability = 0.32, 95% CI = 0.20–0.51).

Conclusions

Poor hypertension control, independent of its consequences, is a risk factor for disability among older people. In addition, hypertension and BMI status have interactive effect on disability among older people. Poor hypertension control is a risk factor among obese individuals, but a protective factor among underweight individuals.

Background

It is well established that disability is associated with increased healthcare costs[1], low quality of life and high mortality[2]. As a result of population aging, advances in medical technology, improvements in lifestyle and wide spread of chronic diseases, the proportion of disability is increasing[3]. Among common chronic diseases, hypertension is the leading preventable risk factor for premature disability and death worldwide[4], approximately 24·1% in men and 20.1% in women had hypertension[5]. More remarkable, while high-income countries have begun to reduce hypertension in their populations through strong public health policies, many developing countries are seeing growing numbers of people who suffer from hypertension[6]. China, a developing country with huge population, is undergoing a dramatic population aging at the same time[7]. The hypertension rate of whole population is 25.2%, and up to 58.9% for those aged 60 or more[8]. Hence, disability issues of hypertensive older population in China should be given high attention.

Compared with younger individuals, older people usually have higher hypertension prevalence and lower rates of control[9, 10]. But, among older people, the association between hypertension and disability is still in debate. Some studies support that hypertension is a definite risk factor of disability just like other age groups. In a population-based study with 12446 adults aged 65 years or more, a history of hypertension was associated with an increased risk of activities of daily living (ADL) disability[11]. Takehito Hayakawa et al also found a significant inverse relationship between hypertension and the decrease in instrument activities of daily living (IADL) scores[12]. In addition, a systematic review shows that antihypertensive therapy is associated with a lower risk of ADL disability compared with control therapy[13]. At the same time, some studies support the opposite views. Jochanan Stessman found that untreated hypertension was not associated with ADL dependence or ADL difficulty[14]. Behnam Sabayan et al. even found that higher blood pressure (BP) is associated lower onset of activities of daily living (ADL) disability among 85-plus Netherlands adults[15]. In consequence, more evidence is needed to illustrate the relationship between hypertension and disability.

In addition, rising obesity prevalence, coupled with increasing hypertension rate, has been observed[16, 17]. Despite the different criteria of obesity, data from all countries indicates that obesity has become a global epidemic[18, 19]. Obesity, not only has been articulated quite clearly associated with disability[20–22], but also is a known risk factor for chronic metabolic disorders, such as hypertension[17]. Generally, we hypothesis hypertension would increase the risk of disability among obesity. However, overweight and obesity in combination with disability was associated with disproportionately high rates of hypertension only in women[23]. In our previous study, for individuals with hypertension, obesity was significantly associated with ADL disability, but not with IADL disability[24]. On further reflection, the control of blood pressure wasn't taken into account in those with hypertension, and this may have affected the outcome.

Hence, in this study, we aim to examine the interactive effect of hypertension and obesity with disability, especially including the control of blood pressure, in a large multi-stage cluster sample of older community-dwelling residents aged 60 years or over in Shanghai, China.

Methods

Study Population

The study population is part of a large-scale survey initiated by Shanghai Municipal Health Commission since 2013. The principal objective of this survey is to assess the demand for care services among the older population of Shanghai, China[25]. This research was conducted from August to October 2018 in Shanghai. Stratified by geographical situation, one district, belonging to downtown areas, was randomly selected from 16 districts. In China, street offices are the major administrative division of districts. And then one street office was randomly selected from this district. About 50% eligible participants from this street office were randomly targeted through use of a local household registry. Details of inclusion criteria, data collection and quality control procedure have been previously reported[24, 25]. In brief, 9408 community-dwelling residents, who aged 60 years or older and had living in Shanghai for more than 5 years, were screened. After excluding missing data on BMI, ADLs/IADLs, or hypertension, there were 8648 were included in the final analysis, with a rate of 91.92%.

Measurement of Hypertension

Having hypertension or not was based on the doctor's diagnosis. Hypertension control was defined as treatment with antihypertensive medication and a measured blood pressure of less than 140/90 mm Hg[9]. Poor hypertension control was defined as a measured blood pressure of 140/90 mm Hg or greater.

Measurement of Obesity

Body height and weight were measured using a wall-mounted stadiometer and a digital floor scale to the nearest 0.1 cm and 0.1 kg, respectively. BMI was calculated as weight divided by height squared (kg/m^2). Using the World Health Organization (WHO) Asia criteria, we categorized BMI into 4 groups: underweight ($<18.5\ kg/m^2$), normal weight ($18.5\text{-}23.0\ kg/m^2$), overweight ($23.0\text{-}25.0\ kg/m^2$), and obese ($\geq 25.0 kg/m^2$) [26].

Measurement of Disability

Disability was referred to as inability to perform ADL and/or IADL, which were assessed by the self-reported physical self-maintenance scale (PSMS) and IADL scale developed by Lawton and Brody[27]. The PSMS included 6 ADL items: toilet, feeding, dressing, grooming, walking, and bathing. The IADL scale included 8 items: ability to use telephone, shopping, food preparation, housekeeping, laundry, using transport, medical care and financial management. The ADL or IADL disability was defined as a disability in any of the 6 ADL items or 8 IADL items[24, 28, 29].

Assessment of Covariates

Covariates in the analyses included age, gender, and living arrangements (with spouse only, with children only, with spouse and children, with other relatives or non-relatives, living alone). Chronic conditions, based on the doctor's diagnosis, included diabetes, coronary heart disease, cerebral infarction, chronic

pneumonia, rheumatoid arthritis, advanced carcinoma, hematencephalon, dementia, hyperthyroidism/hypothyroidism, and chronic obstructive pulmonary disease.

Statistical analysis

Continuous data were presented as unadjusted means ± standard deviations (SD), whereas the categorical variables were present as n and percentage (%). Logistic regression with 95% confidence intervals (CI) was used to determine the risk of hypertension group for ADL/IADL disability by calculating the odds ratio (OR). ORs of hypertension subset for IADL/ADL disability were first unadjusted, and were then adjusted for social demographics, and were further adjusted for chronic conditions. In addition, to explore the potential role of BMI status in mediating the relationship between hypertension and disability, interactive analyses were performed in this study. The level of significance was set at 0.05 (two-tailed). Data were analyzed using SAS 9.2.

Results

Of all participants, 40.2% had hypertension, 9.3% reported ADL disability, 32.5% for IADL disability, and the mean BMI was 23.1±2.5. The descriptive characteristics and differences between different hypertension statuses are shown in Table 1. The poor hypertension control subgroup had a higher prevalence of overweight, obese, ADL disability, and IADL disability.

Influence of Hypertension and BMI Status on ADL disability

Table 2 shows the association between hypertension statuses and ADL disability for all individuals, and individuals in different BMI subgroups. In independent analyses, hypertension control and poor hypertension control were risk factors to ADL disability in bivariate logistic regression. After adjusting for demographics, only poor hypertension control was still a risk factor (OR=1.35, 95% CI=1.03-1.78), and this association was remained after further adjusting chronic conditions (OR=1.47, 95% CI=1.10-1.96). In interactive analyses, the association between different hypertension statuses was more complicated. For normal weight and obese subsets, these associations were similar to the independent analyses. After adjusted for demographics and chronic conditions, compared with without hypertension, poor hypertension control was a risk factor (OR for normal weight group=1.82, 95% CI=1.22-2.70; OR for obese group=1.73, 95% CI=1.09-2.74). However, for underweight subset, poor hypertension control turned into a protective factor in all models. After adjusted for demographics and chronic conditions, compared to without hypertension, OR is 0.33 (95% CI=0.18-0.62), and compared to hypertension control, OR is 0.47 (95% CI=0.24-0.92).

Influence of Hypertension and BMI Status on IADL disability

Table 3 shows the association between hypertension statuses and IADL disability for all individuals, and individuals in different BMI subgroups. In independent analyses, hypertension control and poor hypertension control were risk factors to IADL disability in bivariate logistic regression. After adjusting for

demographics, only poor hypertension control was still a risk factor (OR=1.48, 95% CI=1.21-1.81), and this association was also remained after further adjusting chronic conditions (OR=1.55, 95% CI=1.27-1.91). In interactive analyses, poor hypertension control was a definite risk factor for IADL disability for overweight and obese subsets in all models. After adjusted for demographics and chronic conditions, versus without hypertension, OR of poor hypertension control for overweight subset was 1.58 (95% CI=1.22-2.03), OR for obese subset was 1.80 (95% CI=1.31-2.47); versus hypertension control, OR for overweight subset was 1.55 (95% CI=1.16-2.06), OR for obese subset was 1.41 (95% CI=1.01-1.98). In obese subset, even hypertension control was a risk factor for IADL disability versus without hypertension after adjusted for demographics and chronic conditions (OR=1.27, 95% CI=1.01-1.61). For normal weight subset, hypertension control and poor hypertension control was a risk factor for IADL disability only in unadjusted model versus without hypertension (OR of hypertension control =1.26, 95% CI=1.09-1.45; OR of poor hypertension control =1.52, 95% CI=1.25-1.86). Similarly, both hypertension control and poor hypertension control turned into protective factors in all models among underweight individuals. After adjusted for demographics and chronic conditions, versus without hypertension, OR of hypertension control was 0.72 (95% CI=0.53-0.99), OR of poor hypertension control was 0.32 (95% CI=0.20-0.51); versus hypertension control, OR of poor hypertension control was 0.44(95% CI=0.26-0.73).

Discussion

The major findings of our analysis were that poor hypertension control may negatively influence the independence in ADL/IADL in older adults, but this adverse association could be changed if taking BMI status into account. After adjusted for demographics and chronic conditions, among underweight subset, poor hypertension control turned into a protective factor for ADL/IADL disability not only versus without hypertension, but also versus hypertension control; however, at the same time, among obese subset, poor hypertension control was a certain risk factor for ADL/IADL disability versus without hypertension. Our results thus contribute to the current knowledge by providing evidence that BMI status may completely change the association between hypertension and ADL/IADL disability.

Although hypertension is one of the most important preventable contributors to disease and death[30], several studies also show different result when focusing on the relationship between hypertension and disability[11, 12, 31, 32]. For example, Uddin et al. found hypertension was significantly associated with lower ADL scores in Bangladesh[31]; our previous study indicated that simple hypertension wasn't significantly associated with ADL/IADL disability[24]. In present study, we found only poor hypertension control was associated with ADL/IADL disability, while hypertension control was not. These results remind that the statues of hypertension control might modify the relationship between hypertension and disability among older adults. Based on the finding in our study, we suggest that more attention should be paid to those with poor hypertension control, although the proportion of poor hypertension control subset was low (only 6.54% in our sample).

In further comparison, when BMI status was taken into consideration, the relationship between hypertension and disability became much more complicated. For obese subset, poor hypertension control

indicated a high prevalence rate of both ADL and IADL disability; even hypertension control was associated with IADL disability. As previous studies proved, obesity not only independently predicted the risk of development ADL/IADL disability[21, 33], but also was one of the most common risk factors for hypertension[17]. Our findings prompt that poor hypertension control and obesity show synergistic effects on disability (for ADL disability, OR of the whole participants = 1.47, OR of the obese participants = 1.73; for IADL disability, OR of the whole participants = 1.55, OR of the obese participants = 1.80). Accordingly, taking measures to control blood pressure for obese older adults may deserve special attention.

Generally, underweight is associated with a low prevalence rate of hypertension[34], but also regarded as a red flag of disability[35–37]. In this study, for underweight subset, poor hypertension control indicated a low prevalence rate of disability. This result was completely different with the whole sample. There are several plausible explanations. Firstly, the age of the underweight subset was relatively older. More specifically, the mean age of the underweight subset was 76.09 ± 10.19, while for the normal weight, overweight, and obese subset was respectively 70.12 ± 8.53, 69.06 ± 7.39, and 70.21 ± 7.94. Studies showed, for older individuals, high blood pressure might be a compensatory mechanism to maintain organ perfusion, which can have a survival benefit while ensuring perfusion in critical organs, and ultimately prevention of physical decline[15, 38]. In addition, the share of underweight subset was quite low (only 4.89%). Therefore, the influence of underweight status could be hided among the whole group. The finding reminds that more studies are needed to explore whether or not to take antihypertensive therapy for underweight hypertensive older individuals.

Furthermore, the association of hypertension statuses and ADL disability or IADL disability appeared different changes between normal weight and overweight subsets. For ADL disability, poor hypertension control was a definitely risk factor compared with without hypertension only among normal weight subset; for IADL disability, poor hypertension control was a definitely risk factor compared with without hypertension and hypertension control only among overweight subset. The prevalence rate of IADL disability was over triple that of ADL disability (for ADL disability = 9.27%; for IADL disability = 32.47%). The huge difference between the prevalence rates of ADL and IADL disability may induce the statistical differences. At the same time, it is noteworthy that the different directions of the association showed the distributions of ADL disability and IADL disability among older people might be different. Therefore, we suggest that ADL and IADL should be used together to enforce the integrity and reliability of independence and disability evaluation.

Our study has several limitations that warrant consideration. First, the cross-sectional design of the study limits the causality of the findings and only associations can be drawn, providing hypotheses that can be verified in future studies. A second limitation is more than 700 hypertensive respondents were excluded from this study because of missing blood pressure information, which might cause potential effect to the results. In addition, some characteristics, such as education, nutrition status, and muscle strength, that were associated with ADL/IADL disability, were not included in this survey[39–41].

To our best knowledge, this is the first study aimed at investigating the possible interactive effect of hypertension and BMI status on dependency in activities of daily living among older people. As previously discussed, hypertension control and poor hypertension control could play different roles among different BMI statuses. Thus, these findings provide some evidence that hypertension and BMI status have interactive effect on ADL and IADL disability.

Conclusions

Poor hypertension control, independent of its consequences, is a risk factor for disability among older people. In addition, hypertension and BMI status have interactive effect on disability among older people. Poor hypertension control is a risk factor among obese individuals, but a protective factor among underweight individuals. Accordingly, BMI status should be taken into consideration when choosing hypertension therapeutic strategy.

Abbreviations

ADL: the activities of daily living; BP:blood pressure; BMI:body mass index; IADL:the instrumental activities of daily living; PSMS:the physical self-maintenance scale.

Declarations

Ethics approval and consent to participate

The Ethics Committee of the Shanghai Medical and Technology Information Institute approved this study. Written informed consent was obtained from all participants or their family members (except for the illiterate, who only provided oral consent) before beginning the data collection.

Consent for publication

This manuscript has not been previously published and is not under consideration in the same or substantially similar form in any other peer-reviewed media, and if accepted, the paper will not be published elsewhere in the same form, in English or in any other language, including electronically.

Availability of data and materials

Not applicable.

Competing interests

The authors have no financial interests to disclose.

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Author Contributions

PS, SY, ZD, QW were responsible for the conception of the study design and drafting of the manuscript. SY, YZ, HD were involved in data acquisition. WL, JM, YG, QL were responsible for analysis and interpretation of data. WL, YZ, JM, YG, QL, HD were involved in the editing of the manuscript. All authors read and approved the final manuscript.

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The funders had no role in design or conduct of the study, collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; or decision to submit the manuscript for publication. The contents do not represent the views of the China Department of Veterans Affairs or the China government.

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Tables

Table 1. The Characteristics of participants by the hypertension status

Characteristics	Overall (n=8648)	Without HTP (n=5176)	HTP control (n= 2906)	Poor HTP control (n=566)	P
Age, y (mean ± SD)	70.39±8.38	68.79±7.78	71.46±8.40	73.07±8.94	<.001
Gender					
% Female	51.45	52.07	51.20	47.00	0.069
% Male	48.54	47.93	48.76	53.00	
Living arrangement					<.001
% With spouse only	55.59	55.51	56.09	53.71	
% With children only	10.03	9.06	10.67	15.55	
% With spouse and children	14.29	15.48	12.39	13.25	
% With other relatives/ non-relatives	10.62	10.82	10.01	11.84	
% Living alone	9.48	9.14	10.84	5.65	
Number of other chronic diseases					<.001
% none	83.59	82.38	86.20	81.27	
% one	13.88	15.67	10.77	13.43	
% two or more	2.53	1.95	3.03	5.30	
BMI status					<.001
% underweight	3.19	3.30	3.13	2.47	
% normal	44.66	46.77	41.88	39.58	
% overweight	33.59	33.58	33.17	35.87	
% obese	18.56	16.34	21.82	22.08	
ADL disability, %	9.27	8.13	10.05	15.72	<.001
IADL disability, %	32.47	28.81	36.20	46.82	<.001

Note: M±SD=mean ± standard deviation; ADL=activities of daily living; IADL= instrumental activities of daily living; HTP=hypertension.

Table 2. The Independent and Interactive Effects of Hypertension Status and Body Mass Index on ADL disability

Characteristics	Unadjusted OR (95% CI)	Adjusted OR† (95% CI)	Adjusted OR‡ (95% CI)
Independent effect			
Hypertension status			
HTP control vs. Without HTP	1.32 (1.10, 1.51)	0.89 (0.75, 1.05)	0.98 (0.85, 1.17)
Poor HTP control vs. Without HTP	2.31 (1.84, 2.90)	1.35 (1.03, 1.78)	1.47 (1.10, 1.96)
Interactive effect			
Underweight			
HTP control vs. Without HTP	0.51 (0.36, 0.74)	0.84 (0.55, 1.28)	0.72 (0.46, 1.12)
Poor HTP control vs. Without HTP	0.10 (0.06, 0.16)	0.36 (0.20, 0.64)	0.33 (0.180, 0.62)
Poor HTP control vs. HTP control	0.19 (0.11, 0.34)	0.42 (0.22, 0.47)	0.47 (0.24, 0.92)
Normal			
HTP control vs. Without HTP	1.50 (1.17, 1.91)	1.19 (0.89, 1.59)	1.30 (0.96, 1.76)
Poor HTP control vs. Without HTP	3.57 (2.63, 4.84)	1.83 (1.26, 2.66)	1.82 (1.22, 2.70)
Poor HTP control vs. HTP control	2.38 (1.71, 3.33)	1.53 (1.03, 1.40)	1.40 (0.92, 2.14)
Overweight			
HTP control vs. Without HTP	1.12 (0.91, 1.36)	0.86 (0.68, 1.08)	0.92 (0.72, 1.17)
Poor HTP control vs. Without HTP	1.40 (1.06, 1.84)	0.91 (0.66, 1.25)	0.96 (0.69, 1.34)
Poor HTP control vs. HTP control	1.25 (0.91, 1.72)	1.06 (0.74, 1.04)	1.04 (0.71, 1.52)
Obese			
HTP control vs. Without HTP	1.17 (0.87, 1.57)	1.16 (0.83, 1.62)	1.17 (0.82, 1.66)
Poor HTP control vs. Without HTP	2.08 (1.42, 3.03)	1.69 (1.09, 2.64)	1.73 (1.09, 2.74)
Poor HTP control vs. HTP control	1.78 (1.18, 2.70)	1.46 (0.93, 1.48)	1.48 (0.91, 2.40)

Note: OR=odds ratio; CI=confidence interval; BMI=body mass index; ADL=activities of daily living; IADL= instrumental activities of daily living; HTP=hypertension.

† adjusted for age, gender, and living arrangement.

‡ adjusted for chronic conditions in addition to age, gender, and living arrangement.

Table 3. The Independent and Interactive Effects of Hypertension Status and Body Mass Index on IADL

disability

Characteristics	Unadjusted OR (95% CI)	Adjusted OR† (95% CI)	Adjusted OR‡ (95% CI)
Independent effect			
Hypertension status			
HTP control vs. Without HTP	1.42 (1.29, 1.57)	1.05 (0.94, 1.17)	1.11 (0.99, 1.25)
Poor HTP control vs. Without HTP	2.25 (1.88, 2.68)	1.48 (1.21, 1.82)	1.55 (1.27, 1.91)
Interactive effect			
Underweight			
HTP control vs. Without HTP	0.48 (0.37, 0.63)	0.82 (0.60, 1.11)	0.72 (0.53, 0.99)
Poor HTP control vs. Without HTP	0.12 (0.08, 0.18)	0.33 (0.21, 0.53)	0.32 (0.20, 0.51)
Poor HTP control vs. HTP control	0.25 (0.16, 0.40)	0.41 (0.25, 0.44)	0.44 (0.26, 0.73)
Normal			
HTP control vs. Without HTP	1.26 (1.09, 1.45)	1.02 (0.87, 1.19)	1.07 (0.91, 1.25)
Poor HTP control vs. Without HTP	1.52 (1.25, 1.86)	1.09 (0.86, 1.37)	1.11 (0.88, 1.41)
Poor HTP control vs. HTP control	1.21 (0.96, 1.52)	1.07 (0.82, 1.04)	1.04 (0.80, 1.36)
Overweight			
HTP control vs. Without HTP	1.27 (1.08, 1.50)	0.97 (0.81, 1.17)	1.02 (0.85, 1.23)
Poor HTP control vs. Without HTP	2.69 (2.16, 3.36)	1.58 (1.23, 2.03)	1.58 (1.22, 2.03)
Poor HTP control vs. HTP control	2.12 (1.65, 2.73)	1.62 (1.22, 1.55)	1.55 (1.16, 2.06)
Obese			
HTP control vs. Without HTP	1.31 (1.07, 1.61)	1.24 (0.98, 1.56)	1.27 (1.01, 1.61)
Poor HTP control vs. Without HTP	2.01 (1.52, 2.65)	1.76 (1.28, 2.40)	1.80 (1.31, 2.47)
Poor HTP control vs. HTP control	1.53 (1.14, 2.06)	1.42 (1.02, 1.41)	1.41 (1.01, 1.98)

Note: OR=odds ratio; CI=confidence interval; BMI=body mass index; ADL=activities of daily living; IADL= instrumental activities of daily living; HTP=hypertension.

† adjusted for age, gender, and living arrangement.

‡ adjusted for chronic conditions in addition to age, gender, and living arrangement.