

# Prevalence and Related Risk Factors Associated with Coronary Heart Disease (CHD) Among Middle Aged and Elderly Patients with Vision Impairment (VI)

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## Research article

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# Abstract

**Objective:** To investigate the prevalence and related risk factors associated with coronary heart disease (CHD) among middle aged and elderly patients with vision impairment (VI).

**Study design:** cross-sectional research.

**Methods:** The study was conducted with 1,355 visually impaired adults over 45 years old, recruited from a Rehabilitation Hospital in China. Visual impairment is diagnosed by a doctor according to guidelines. Data was analyzed using multiple correspondence and logistic regression analysis. This research represents an important step towards the development of empirically based practical suggestions for decision-makers and health professionals that support visually impaired middle-aged and elderly people to participate in physical exercise and weight management when needed.

**Results:** Of the 1335 middle aged and elderly adults with VI, a total of 154 (11.5%) developed CHD. Statistical analysis based on age grouping indicated that hypertension, diabetes, blindness, gentle and moderate activity were shown to have a strong association with development of CHD. In addition, fasting plasma glucose, heart rate (<60), and BMI were important risk factors for CHD in the middle-aged group and the elderly group respectively.

**Conclusion:** Suggestions for related policy changes should focus on the social and environmental aspects. This includes developing a more accessible and inclusive environments and providing meaningful information about physical activity and weight management to middle-aged and elderly people with visually impaired.

## Introduction

Coronary heart disease(CHD) is caused by a kind of inflammatory responses in vascular endothelium caused by atherosclerosis of coronary artery. It is one of the most frequent cardiovascular diseases in clinical practice, which is also regarded as a major cause of morbidity and mortality worldwide.<sup>1,2</sup> In China, there has been a rapid and significant increase in the burden of CHD over the past 20–30 years.<sup>3,4</sup> Numerous studies have demonstrated that CHD can be effectively prevented by the effective management of risk factors and timely treatment regimes. That is, the early and accurate detection of individuals who are at high risk is critical for preventing the development of CHD.

Hypertension, diabetes, hypercholesterolemia, obesity, unhealthy diet and physical inactivity have been well-established as important and modifiable risk factors for cardiovascular disease.<sup>3,5</sup> The majority of studies is specifically focused on either healthy populations or a general population. However, the incidences of physical inactivity, obesity, and diabetes are just as prevalent in patients with disabilities. Health disparities between people with and without vision impairment has been proved in several studies.<sup>6–8</sup> Visual acuity is a reflection of functional status and ocular health, and it has been proven that vision impairment onset is caused by physiological changes associated with aging and underlying

chronic diseases.<sup>9</sup> Studies have demonstrated persons with vision impairment (VI) had poorer overall survival and higher VI-cause mortality, compared with those without.<sup>10,11</sup> People living with vision impairment may be more vulnerable to various chronic diseases and may be overlooked, due to activity limitations or participation restriction in the absence of supportive personal and environmental factors.

The number of VI has increased significantly, and understanding differences versus the general population is particularly important. However, to our knowledge, there are few literatures comparing the incidence and risk factors of CHD among people with and without VI, especially in developing countries such as China. Hence, more details are needed to explore the CHD burden and risk factors in visually impaired people. The aim of the current cross-sectional study was to identify the prevalent and related risk factors of CHD among VI, and to further analyzed the effects of different age groups on this relationship, so as to provide reference for proposing intervention strategies and reducing coronary heart disease in VI population.

## Methods

### Study Population

We performed a cross-sectional study among a total of 1335 adults with medically diagnosed vision impairment in one or both eyes, using data collected from January 1, 2018 to December 31, 2018 at Shanghai Yangzhi Rehabilitation Hospital in China. Each disabled person received medical examination including physical examination, imageological examination and blood routine examination. This study was approved by the Ethics Committee of Shanghai Yangzhi Rehabilitation Hospital (YZ2019-051). Written informed consent was obtained from participants, after having had the procedure and risks explained to them in their native language, and all the participants were mature adults.

Patients who met the following criteria were included in the study: medically diagnosed vision impairment in one or both eyes (including low vision and blindness); can walk independently with or without mobility aids; aged 18 and older; can speak Chinese. Exclusion criteria included: patients with severe additional impairments, such as hearing, physical and mental disabilities; those with severe heart, brain and kidney disease.

### Measurements

The sociodemographic characteristics of participants were collected via a questionnaire. Anthropometric parameters including body mass index (BMI), diastolic blood pressure (DBP) and systolic blood pressure (SBP) were collected by the medical examination using standard protocol. All blood samples were obtained in the morning following an overnight fasting of at least 12 h. Total cholesterol (TC), total triglyceride (TG), fasting plasma glucose (FBG), uric acid (UA), serum urea (SU), hemoglobin (Hb), red blood count (RBC), white blood count (WBC), platelet count (PLT) were collected by the medical examination. BP was recorded twice on the right arm after 5 minutes resting. Two readings were obtained 30 seconds apart. Blood routine examination was taken in the morning after an overnight fasting of at

least 12 h. Body mass index (BMI) was calculated based on height and weight. Serum biochemical indexes, such as FBG, TC, TG, Alb, Glo, UA, CR, SU, Hb, RBC, WBC, PLT were measured enzymatically (Roche Corporation, Basel, Switzerland).

Information on physical activity was obtained from patient interviews. Adults with disabilities unable to meet the Physical Activity Guidelines should regularly engage in physical activity according to their abilities and avoid inactivity.<sup>12</sup> Based on standard, activity outcomes were derived: sedentary behaviour (mainly in bed or wheelchair, self-care needs help) is defined as any waking behaviour with an energy expenditure  $\leq 1.5$  metabolic equivalent, gentle activity intensity aerobic physical activity (rates of perceived exertion  $< 12$ , 40–60% of the maximum heart rate), moderate to high intensity aerobic physical activity (rates of perceived exertion  $\geq 12$ , 60–75% of the maximum heart rate).<sup>13</sup>

## Definitions

### Diagnostic criteria of disease

Prevalence of hypertension, diabetes mellitus (DM), Hyperlipidemia (HPL), coronary heart disease (CHD) was checked by clinical doctors. Hypertension was defined as either SBP  $\geq 140$  mmHg or DBP  $\geq 90$  mmHg, or long-term use of antihypertensive drugs, or previous medical diagnosis of hypertension.<sup>14</sup> Diabetes was defined as fasting blood sugar levels  $\geq 7.0$  mmol or previous medical diagnosis of diabetes.<sup>15</sup> Dyslipidemia was defined as total cholesterol (TC)  $\geq 5.7$  mmol or total triglycerides (TG)  $\geq 1.7$  mmol/L, or high-density lipoprotein cholesterol (HDL-C)  $< 0.91$  mmol, or low density lipoprotein cholesterol (LDL-C)  $> 3.6$  mmol.<sup>16</sup> Prevalence of CHD was defined as history of CHD or clinical doctor's diagnosis by the imageological examination.

### Vision impairment

According to China's survey of disabled persons in 2006, vision impairment is defined as the impairment of binocular vision or narrowing of the field of vision due to various reasons that cannot be corrected, thus affecting the subject's daily life and social participation. Vision impairment is classified as low vision and blindness. Low vision can be further divided into two categories: severe visual impairment (SVI) ( $3/60 \leq \text{BCVA} < 6/60$ ) and moderate visual impairment (MVI) ( $6/60 \leq \text{BCVA} < 6/18$ ). Blindness can also be further divided into two categories: profound visual impairment (PVI) ( $12/600 \leq \text{BCVA} < 3/60$ ) and near total blindness (NTB) ( $\text{BCVA} < 12/600$ ). The grade of vision impairment is determined based on the measurements from both eyes; if there are discrepancies between each eye, the vision measurements from the better eye is chosen. If only one eye was classified as low vision or blind but the other eye had a vision of 0.3 or better, the subject was not classified as having a vision impairment. Best corrected visual acuity (BCVA) is the highest visual acuity that can be achieved with proper lens correction, or measured with a pinhole mirror. Subjects with a visual field radius of less than 10 degrees, regardless of their vision are classified as being blind. The classification of vision impairment is shown in Table 1.

Table 1  
Grade of visual disability.

Category	Grade	BCVA
Blindness	1(NTB)	no light perception ~ 0.02; or SR < 5
	2(PVI)	$0.02 \leq BCVA < 0.05$ ; or SR < 5
Low vision	3(SVI)	$0.05 \leq BCVA < 0.1$
	4(MVI)	$0.1 \leq BCVA < 0.3$
Abbreviations: BCVA: best corrected visual acuity; NTB: near total blindness; SR: Sight radius; PVI: profound visual impairment; SVI: severe visual impairment; MVI: moderate visual impairment.		

Table 2  
Classification of recorded independent variables.

Variables	Assignment classification
Gender	1 = Male, 2 = Female
Education level	1 = Primary or less, 2 = Secondary or over
Degree of disability	1 = Blindness, 2 = low vision
BMI	1= (< 18.5) ,2= (18.5–24.0), 3= (24.1–27.9), 4= (> 28)
Physical activity	1 = sedentary, 2 = gentle, 3 = moderate to high intensity
UA(mol/ L)	1= (< 428 mol/L for male, < 357 mol/L for female) 2= ( $\geq$ 428 mol/L for male, $\geq$ 357 mol/L for female)
SU(mmol/ L)	1= (< 7.1 mmol/L), 2= ( $\geq$ 7.1 mmol/L)
Hb(g/L)	1= (< 175 g/L for male, < 150 g/L for female) 2= ( $\geq$ 175 g/L for male, $\geq$ 150 g/L for female)
RBC( $10^{12}$ /L)	1= (< $5.8 \times 10^{12}$ /L for male, < $5.1 \times 10^{12}$ /L for female) 2= ( $\geq$ $5.8 \times 10^{12}$ /L for male, $\geq$ $5.1 \times 10^{12}$ /L for female)
WBC( $10^9$ /L)	1= (< $9.5 \times 10^9$ /L), 2= ( $\geq$ $9.5 \times 10^9$ /L)
HR(times/min)	1= (< 60), 2= (60–90), 3= (> 90)
Abbreviations: BMI: body mass index; UA: uric acid; SU: serum urea; Hb: hemoglobin; RBC: red blood count; WBC: white blood count; HR: heart rate.	

## Statistical Analysis

Continuous variables with normal distribution were expressed as the mean  $\pm$  SD and comparisons between groups were performed by independent student's t-tests. In case of skewed distribution,

continuous variables were presented as median (inter-quartile range) and the comparison between groups were conducted using Mann–Whitney U-test. These newly formed categorical variables were picked into a multiple correspondence analysis (MCA) model (on the basis of optimal scaling) to investigate the interrelationships among the factors considered through a visualized two-dimensional graph. This kind of analysis is mainly descriptive and resumes information on association among factors considered through a graphical representation.  $\chi^2$ -test for trend (linear-by-linear test) was used as a substantial supplementation to examine the possible direct viewing association appeared in the MCA plot. Finally, Multiple logistic regression analysis model was performed to evaluate whether the latent independent risk factors were associated with CHD. Variables that demonstrated significant statistical differences between groups (non-CHD versus CHD) were selected and entered into multivariate logistic regression models for the assessment of independent risk factors of CHD. Two-sided *P* value less than 0.05 was considered statistically significant. All statistical analyses were conducted using SPSS 25.0 statistical software (Chicago, IL, Illinois, USA).

## Results

The demographic and clinical features of all subjects with non-CHD or CHD are summarized in Table 3 to Table 5. As shown in Table 3, a prevalence rate of 11.5% (154/1335) was given, with the rate for middle aged 8.6% (68/791) and elderly adults 15.8% (86/544). The prevalence of CHD was proven to increase significantly with age. Comparisons between patients with or without CHD indicated that age were significantly higher in patients with CHD than those without CHD. To explore the associated risk elements of CHD between younger and elderly populations, we divided the populations into two groups based on age (< 65 and  $\geq$  65 years) and conducted subgroup analysis.

Table 3  
The prevalence of Coronary heart disease (CHD) stratified by age and gender.

Age Group	Total (n = 1335)		Male (n = 609)		Female (n = 726)	
	No.	Prevalence	No.	Prevalence	No.	Prevalence
40 ~ 65 <sup>a</sup>	68	8.6%	25	7.4%	43	9.5%
$\geq$ 65 <sup>a</sup>	86	15.8%	37	13.7%	49	17.9%
Sum <sup>a</sup>	154	11.5%	62	10.2%	92	12.7%

<sup>a</sup>. there were statistically significant differences in prevalence of CHD among different age groups, *P* < 0.001.

Among the total of 1335 patients with VI, the average age was  $63.56 \pm 7.74$  years; 45.6% of the participants were men; average BMI was  $24.14 \pm 3.22$  kg/m<sup>2</sup>. Subjects with CHD had a higher rate of hypertension (64.9%), DM (31.2%), comparing to 42.1%, 11.5% in subjects with Non-CHD. Table 4 depicted that age, degree of disability and physical activity, BMI, SBP in subjects with CHD was

significantly higher than that in those without Non-CHD ( $P < 0.05$ ). All of the remaining variables except for FPG, TC, TG, and SU were also significantly higher in subjects with CHD (Table 5).

Table 4  
Baseline characteristics of the two groups of subjects.

Characteristic	Total (n = 1335)	CHD (n = 154)	Non-CHD (n = 1181)	P-value
<b>Age(years)</b>	<b>63.56 ± 7.74</b>	<b>66.16 ± 7.49</b>	<b>63.22 ± 7.72</b>	<b>0.000</b>
Gender (male, %)	609(45.6)	62(40.26)	547 (46.32)	0.156
Education grade(%)				0.488
Primary or less	405(30.3)	43 (27.92)	362 (30.65)	
Secondary or over	930(69.7)	111 (72.08)	819 (69.35)	
<b>VI(%)</b>				<b>0.000</b>
Blindness (1–2)	374(28.0)	62 (40.26)	312 (26.43)	
low vision (3–4)	961(72.0)	92 (59.74)	869 (73.58)	
<b>PA(%)</b>				<b>0.000</b>
Sedentariness	104(7.8)	41(26.62)	63(6.33)	
Gentle activity	599(44.9)	57(37.01)	542(45.89)	
Moderate-high	632(47.3)	56(36.36)	576(48.77)	
Disease history (%)				
<b>Hypertension</b>	<b>597(44.7)</b>	<b>100(64.94)</b>	<b>497(42.08)</b>	<b>0.000</b>
<b>Diabetes</b>	<b>184(13.8)</b>	<b>48(31.17)</b>	<b>136(11.52)</b>	<b>0.000</b>
Hypercholesterolemia	96(7.19)	7(4.55)	89(7.54)	0.177
<b>BMI (kg/m<sup>2</sup>)</b>	<b>24.14 ± 3.22</b>	<b>25.12 ± 3.50</b>	<b>24.09 ± 3.17</b>	<b>0.001</b>
<b>SBP (mmHg)</b>	<b>126.86 ± 15.28</b>	<b>128.42 ± 15.79</b>	<b>126.66 ± 15.21</b>	<b>0.045</b>
DBP (mmHg)	75.79 ± 8.71	74.74 ± 9.37	75.93 ± 8.61	0.114
HR (times/min)	72.13 ± 11.31	70.86 ± 11.82	72.30 ± 11.24	0.140
Continuous variables were represented as the mean ± SD. Categorical variables were represented as the number of patients (column percentage).				
Abbreviations: VI: vision impairment; PA: Physical activity; BMI: body mass index; SBP: systolic blood pressure; DBP: diastolic blood pressure; HR, heart rate.				

Table 5  
Baseline characteristics of laboratory tests in different groups.

Variables	Total (n = 1335)	CHD (n = 154)	Non-CHD (n = 1181)	P value
FPG (mmol/l)	5.69 ± 1.65	6.01 ± 2.14	5.56 ± 1.57	0.012
TC (mmol/l)	5.15 ± 0.99	5.17 ± 0.98	4.98 ± 1.10	0.040
TGs (mmol/l)	1.42(0.97,2.09)	1.53 (1.02, 2.40)	1.31(0.92, 1.96)	0.026
SG	30.00 ± 3.72	29.61 ± 3.78	30.06 ± 3.71	0.160
SA	43.71 ± 2.39	43.66 ± 2.29	43.71 ± 2.41	0.783
TP	7.71 ± 4.18	73.27 ± 4.29	73.77 ± 4.17	0.160
UA	313.15(258.70, 370.72)	315.55 (256.90, 370.57)	312.35 (258.90, 370.98)	0.828
SCr	61.70(51.30, 73.52)	62.40 (52.47, 72.75)	61.70 (51.10,73.60)	0.727
<b>SU</b>	<b>5.00 (4.00,6.00)</b>	<b>5.0(4.0,6.0)</b>	<b>5.0 (5.0,6.0)</b>	<b>0.016</b>
HGB	140.03 ± 14.48	138.05 ± 14.04	140.28 ± 14.52	0.072
RBC	4.64 ± 0.45	4.60 ± 0.45	4.65 ± 0.45	0.195
WBC	6.41 ± 1.72	6.31 ± 1.54	6.42 ± 1.74	0.462
PLT	222.00(184.00,262.00)	223.00(185.25,259.25)	222.00(184.00,262.00)	0.801
Continuous variables with normal distribution were expressed as the mean ± SD. In case of skewed distribution continuous variables were presented as median (inter-quartile range).				
Abbreviations: FPG, fasting plasma glucose; TC, total cholesterol; TGs, triglycerides; SG, serum globulin; SA, serum albumin; TP, total protein; UA, uric acid; SCr, serum creatinine; SU, serum urea; HGB, hemoglobin; RBC, red blood cell; WBC, white blood cell; PLT, blood platelets.				

Further analysis of MCA graphical displays in Fig. 1 and Fig. 2 after categorizing continuous data. (The explanation of MCA plot followed the protocol that association between two points of the same quadrant in the coordinate was perceived by the distance between them, namely the larger the distance, the less associated the two points are suggested to be.<sup>17</sup> Since MCA is not a hypothesis test but a method of statistical description, a necessary statistical verification was offered and the outcomes are presented in Table 6. Further analysis of multivariate logistic regression models were performed to clarify the relationships between the statistically significant variables and CHD (Table 6). In age group

Table 6  
Risk of developing Coronary heart disease (CHD) according to age categories.

	<65 years(n = 791)			≥ 65 years(n = 544)		
Variables	Multi-adjusted(OR)	95% (CI)	P - value	Multi-adjusted(OR)	95% (CI)	P - value
BMI (kg/m <sup>2</sup> )	–	–	–	1.107	1.031–1.219	0.033
FPG (mmol/l)	1.363	1.014–1.995	0.020	–	–	–
Hypertension	2.046	1.540–4.134	0.012	2.263	1.283–3.993	0.005
Diabetes	7.651	3.341–17.520	0.000	3.182	1.671–7.275	0.001
<b>VI(%)</b>						
3–4(low vision)	–	–	–	–	–	–
1–2(Blindness)	2.642	1.540–4.534	0.000	2.642	1.540–4.534	0.000
<b>PA</b>						
Sedentariness	–	–	–	–	–	–
Gentle activity	0.919	0.826–0.995	0.023	0.715	0.657–0.830	0.000
Moderate activity	0.895	0.754–0.912	0.016	0.772	0.565–0.920	0.021
<b>HR</b>						
60–90						
≥90	0.907	0.322–1.553	0.853	–	–	–
<60	1.848	2.117–3.167	0.041	–	–	–

Abbreviations: BMI: body mass index; FPG, fasting plasma glucose; VI: vision impairment; PA: Physical activity; HR, heart rate.

## Discussion

In the current study, we found that the prevalence of CHD in VI patients was 11.5% (154/1335), which was various according to the difference of demographic characteristics. The related risk factors of CHD included hypertension, diabetes, visual impairment and physical exercise. In addition, there were statistically significant differences between FPG and HR (< 60) in age group <65 years, and the BMI of subjects with CHD was significantly higher in age group  $\geq 65$  years. The results of this study add to the current literature on visual impairment from the prevalence of coronary heart disease and related risk factors in middle-aged and elderly patients with visual impairment.

We founded that whether it is in the middle-aged group or the elderly group with impaired vision, the history of hypertension and diabetes were independent risk factors for coronary heart disease, which is consistent with previous studies.<sup>18-20</sup> We also confirmed that the increase level of fasting plasma glucose (FBG) was closely correlated with risk of CHD in < 65 years group. These consistent conclusions might suggest combined assessment of these indicators may allow the timely detection of CHD among patients with VI.

Our data also suggested that different levels of visual impairment and physical activity were closely related to coronary heart disease. Those participants with low visual impairment and mild to moderate physical activity have a lower risk of coronary heart disease. The disability with reduced vision may be a key barrier to an active lifestyle in adults, and is prominently manifested by increased sedentary behavior. Moreover, this population experiences activity limitations in walking, and environmental barriers such as transport and lack of accessible exercise equipment can hamper a person's ability to be physically active.<sup>21,22</sup> The visually impaired people who are blind may have more significant environmental obstacles such as walking, transportation, and accessible sports equipment, which greatly reduces their chances of participating in physical activities<sup>23,24</sup>. In addition, studies have shown that visually impaired people with sedentary habits are more likely to have multiple complications (such as hypertension and diabetes), which also greatly increases the risk of coronary heart disease.<sup>8,25,26</sup> Healthy People 2020 objective PA-11 calls for increasing the proportion of physician office visits that include counseling or education related to physical activity. This suggests that attention should be paid to people with impaired vision who have less physical activity, especially blind people who are sedentariness.

Notably, we found that HR (< 60) was associated with CHD in the < 65 years old group. It is well accepted that atherosclerotic plaques are viscoelastic, heart rate and heart rate variability (HRV) reduction and atherosclerotic cardiovascular disease (CHD).<sup>20</sup> A high resting heart rate is associated with an increase in cardiovascular mortality in the general population.<sup>21,22</sup> Scientific evidence has shown that a high resting heart rate is a risk factor for the pathogenesis of atherosclerosis, while reductions in resting heart rate decreased vascular oxidative stress and prevented atherosclerosis in animal models.<sup>23</sup> However, our investigation failed to find that the increased heart rate of the visually impaired population increases the risk of coronary heart disease. There are limited data on whether the heart rate of visually impaired people affects coronary heart disease. Future research should pay more attention to the difference in

heart rate monitoring between visually impaired people and normal people as well as the underlying physiological mechanisms.

Indeed, a strong and persistent association between BMI and coronary heart disease has been reported and it is generally regarded as a predictor of cardiovascular disease. Our study further strengthened the notion that BMI was the important predictor of CHD. These findings indicate that effective control of body weight is crucial for the early prevention of coronary heart disease. The association between BMI and coronary risk is mostly mediated through its adverse effects on other major cardiovascular risk factors, mainly diabetes, blood pressure and lipids<sup>27</sup>—which explains that in the elderly group, obese people with visual impairment have a higher risk of coronary heart disease compared with normal weight. Due to differences in study populations, the generalization of this research result has been limited. To support this notion, more multiple-center collaborative study needs to be carried out in the future.

Our study has several potential limitations. First, our study uses a cross-sectional design, and thus it is impossible to infer causal and temporal relationships of risk factors with CHD. Second, our research is based on a sample of visually impaired patients from a hospital in Shanghai, China's largest city, so our findings may not be representative of the general population. Finally, due to limited data availability, we cannot consider the influence of several risk factors such as dietary habits, high-density lipoprotein cholesterol (HDL-), low-density lipoprotein cholesterol (LDL-C), psychological factors and genetic factors. Further research is needed to study the influence of these factors on CHD in VI patients.

## Conclusion

In summary, our study demonstrates that middle aged and elderly patients with vision impairment have a relatively high risk of coronary heart disease (11.5%). Our findings indicate that visual impairment must be addressed in public health policies for middle-aged and elderly people, in particular the burden of CHD with severe visual impairment and lack of physical activity. Vision impaired middle-aged and elderly people could further be targeted through interventions that which these interventions involve multi-sectoral collaboration (such as local organizations, medical staff, etc.) to help lead the group's active social activities.

Further longitudinal studies are needed to confirm causality and understand the potential pathways underlying associations between visual impairment (VI) and coronary heart disease (CHD) and poor physical functioning including frailty. Future longitudinal studies should also investigate whether the observed associations with obesity heart rate, could be explained by inflammatory markers.

## Declarations

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## Disclaimer

The findings and conclusions in this paper are those of the author(s) and there are no conflicts of interest. This manuscript, including data and tables, has not been published elsewhere in whole or part, and is not under review for publication elsewhere.

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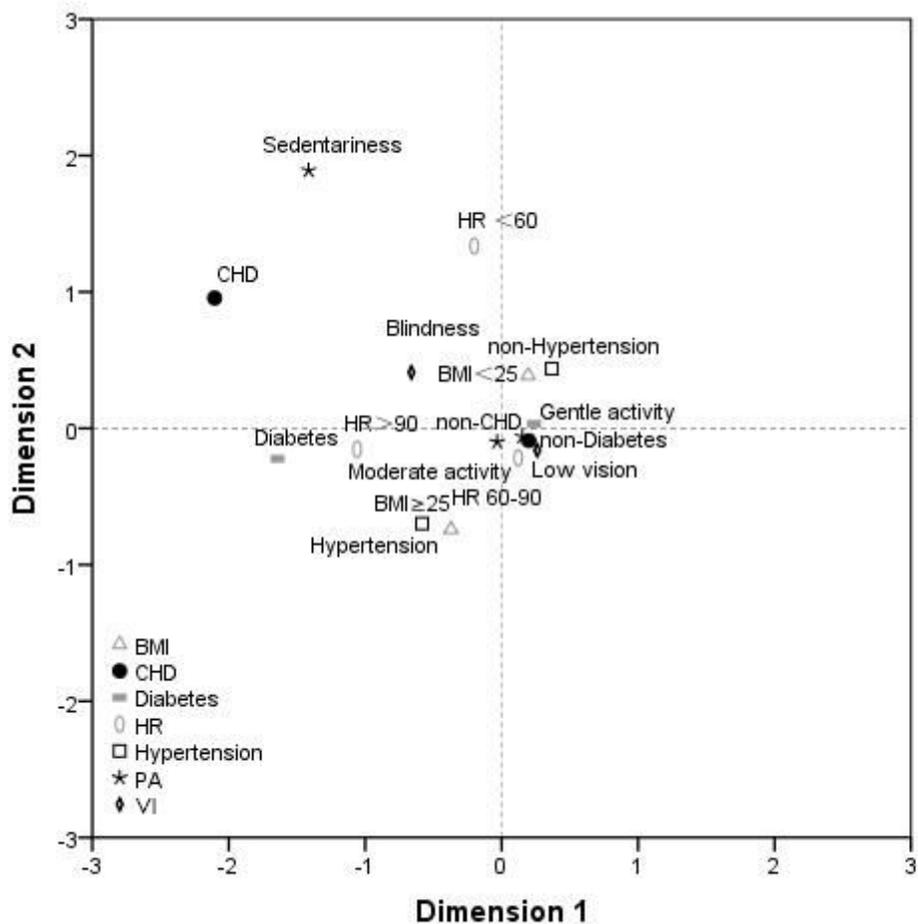
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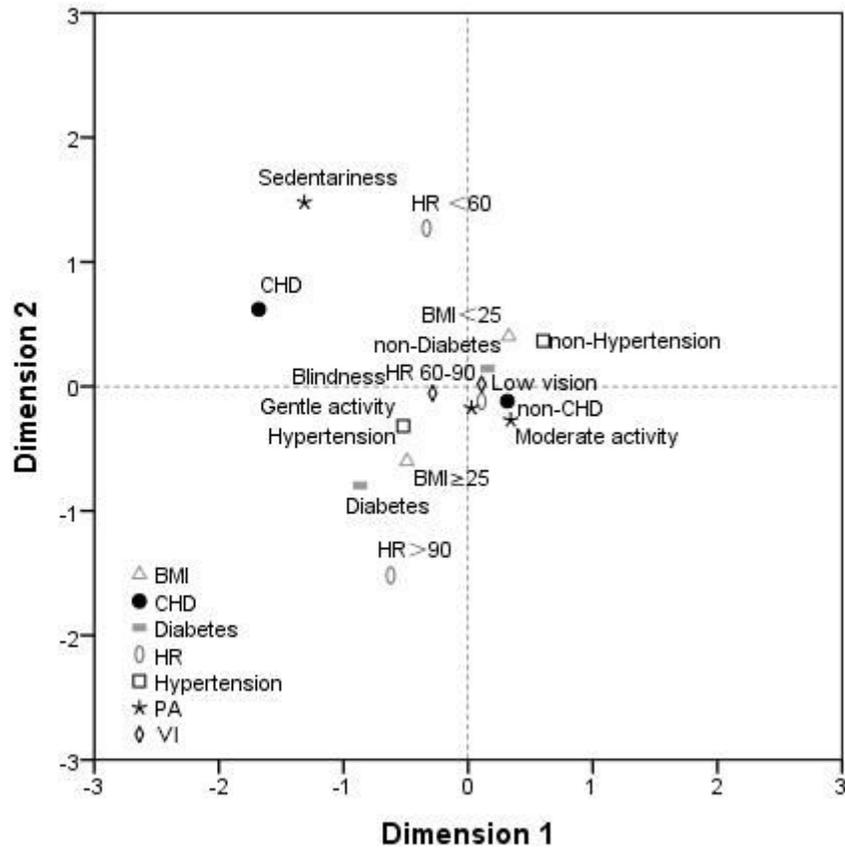
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## Figures



**Figure 1**

Multiple correspondence analysis plot. The continuous variables were transformed into categorical variables according to the acknowledged medical guideline (e.g., BMI, Hypertension). These categorical variables entered into the multiple correspondence analysis (MCA) model (based upon optimal scaling) to evaluate the potential association with CHD or Non-CHD (<65 years).



**Figure 2**

Multiple correspondence analysis plot. The continuous variables were transformed into categorical variables according to the acknowledged medical guideline (e.g., BMI, PA). These categorical variables entered into the multiple correspondence analysis (MCA) model (based upon optimal scaling) to evaluate the potential association with CHD or Non-CHD ( $\geq 65$  years).