The associations of physical activity and the risk of CVD among Chinese population: a cross-sectional study

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Abstract

Background: Previous studies in Western suggest the association between physical activity (PA) and cardiovascular diseases (CVD). However, limited evidence is available among Chinese adults.

Objective: To evaluate the relationship between PA and the risk of CVD among Chinese adults.

Methods: A total of 3568 adults were recruited from seven counties and districts in Jiangsu Province of China using a stratified multistage cluster sampling method. Information of PA, anthropometric measurements and laboratory indices were collected according to standard protocols. Three latent classes of PA were identified using the latent class analysis (LCA) method, and the risk of CVD in the next 10-year was calculated by the Framingham risk score (FRS).

Results: Three latent classes of PA were identified: CLASS1 represented participants with high occupational and low sedentary PA (32.1% of male, 26.5% of female), ClASS2 consistently engaged in low occupational and high leisure-time PA (27.0% of male, 14.2% of female). CLASS3 had low leisure-time and high sedentary PA (40.9% of male, 59.3% of female). The FRS in male were higher than that in female across three Latent Classes. CLASS1 (OR=0.694, 95%CI: 0.553-0.869) and CLASS2 (OR=0.748, 95%CI: 0.573 -0.976) were both the protective factors for CVD in males, however, such association was not observed among females.

Conclusion: Higher occupational or leisure-time PA were associated with decreased risk of CVD, whilst more sedentary behaviour may increase the risk of CVD among Chinese adults.

Highlights

1. This is one of the first studies to identify the associations between CVD and PA among Chinese adults using LCA with representative data.
2. Three Latent classes were identified semi-quantitatively by gender to describe the association between PA and CVD.
3. Higher occupational and leisure-time PA can be protective to CVD, whilst more sedentary behaviors may increase the risk of CVD.

Introduction

Partly due to the expansion of civilization and the advent of industrial technology era, changes of lifestyle have spawned activity patterns far different from those of the last century, with the spread of more artificial intelligence undermining basic physical activity and making sedentary lifestyles a common feature of industrialization [1]. This undesirable behavior pattern is accompanied by an increased morbidity of cardiovascular diseases (CVD). Previous studies showed that regular physical activity (PA) is important for the prevention of various chronic diseases, including CVD [2, 3].

CVD includes coronary heart disease, cerebrovascular disease, rheumatic heart disease and other conditions [4]. With the continuous improvement of people's living standard, population aging and acceleration of urbanization, the incidence of CVD increases year by year, coming with a trend of getting younger [5]. According to the *National Report on Cardiovascular Diseases (2018)* in China [6], the number of patients with CVDs in China had reached 290 million. At present, CVD accounts for up to 40% of all deaths in both urban and rural populations in China, much higher than cancer and other diseases [6].

Bennett et al used to categorize PA into occupational, commuting, household, and recreational PA [7]. *The Global Burden of Diseases Report* estimated that low levels of PA accounted for 1.26 million premature deaths and 2.37 million disability-adjusted life-years worldwide in 2017 [8]. It was found that higher levels of both occupational and leisure-time PA have been associated with lower risk of CVD in high-income countries [9], however, the relevance of occupational and non-occupational PA to the risk of subtypes of CVD, both overall and among different population subgroups (e.g., different ages or levels of blood pressure) in China, has been scarcely reported [7, 10].

Latent class analysis (LCA) uses latent class model (LCM) to explain the relationship between explicit class variables with intrinsic latent class variables [11]. LCA aims to identify subgroups of people who share common characteristics in such a way that people within the subgroups have a similar scoring pattern on the measured variable, while the difference in scoring patterns between the subgroups are as distinctly different as possible [12]. LCA analysis uses a mixture of distributions to identify the most likely model describing the heterogeneity of data as a finite number of classes (subgroups); this is known as finite mixture models [13]. LCA was used for modeling the 'lifestyle' variable in Miranda's study to assess the lifestyle of female adolescents based on measurements of behavioral variables [14]. Moreover, LCA in 2 community samples by Breslau aimed to examine empirically the structure underlying posttraumatic stress disorder (PTSD) criterion symptoms and identify discrete classes with similar symptom profiles [15]. Attempts have also been made in a cohort study which was conducted using 2003–2008 data from the National Violent Death Reporting System, including 28703 suicide decedents from 12 US states [16].

This study aimed to estimate the latent PA types of adult residents in Jiangsu province of China by the LCA, as well as to explore the associations of different latent PA types with the risk of CVD.

Materials And Methods

This study employed face-to-face questionnaire survey, anthropometric measurements and laboratory tests.

Participants

Participant were recruited from seven points of the *National Disease Surveillance System for Chronic Diseases and Risk Factors* in the northern and middle areas of Jiangsu Province of China in 2010 [17]. Using a multistage stratified cluster sampling method, five townships (in rural areas) / streets (in urban areas) were randomly selected from each county/district; followingly, two administrative villages or neighbor communities were randomly selected from each township/street. There were 60 households randomly selected from each village/neighborhood communities and one adult resident (≥ 18 years old) was selected from each household for participation using the KISH table method [18].

Of the 4200 participants recruited, 574 individuals were excluded for aged beyond 30 to 74 (according to the Framingham scoring criteria [19]), 29 for existing CVD, 23 for cancers and other severe comorbidities 6 for invalid information of laboratory tests. Eventually, a number of 3568 participants were included in this study.

Questionnaire survey

The questionnaire was designed according to the China Chronic Noncommunicable Disease and Risk Factor Surveillance (2010) [17], and was conducted by interviewers who received unified training. Information of gender, age, education level, marital status, region, smoking status, drinking status, physical activity status, daily sedentary behaviors, hypertension, diabetes, and dyslipidemia were included in the questionnaire.

The *Global Physical Activity Questionnaire(GPAQ)* [20] was used to assess the intensity and duration of several components of physical activity, including (1) occupational, agriculture and housework activity; (2) commuting physical activity; (3) leisure-time physical activity; (4) sedentary behaviors. Levels of agreement with objective measurements indicate that the GPAQ is a valid measure of moderate-to-vigorous physical activity and its change [21].

Anthropometric measurements

Height, body weight, waist circumference and blood pressure were measured by anthropometric investigators using instruments of unified brands and models, while all investigators completed a training program successfully that familiarized them with both the specific tools and methods used and the aims of this study.

The height was measured by a height meter with a maximum range of 2.0 m and a minimum scale of 0.1 cm.The body weight was measured by an electronic scale with a maximum range of 150 kg and an accuracy of 0.1 kg.The waist circumference was measured by a leather tape measure horizontally around the abdomen and placed at the midpoint of the line between the anterior superior iliac crest and the lower 12th costal margin. Blood pressure was measured using an automated device (OMRON HEM-7207) [22] at left arm 3 times consecutively according to the standard protocol, with an 1 to 2 minutes interval between two measurements with the participants at a seated position after at least 5 minutes rest. All sphygmomanometer is calibrated by the manufacturer and checked by the national quality assurance team department. The mean value of the three measurements was used as the final blood pressure values. Details of the anthropometric measurements had been documented elsewhere [23].

Blood sample collection and tests

A volume of 4 ~ 5 ml venous blood sample was collected in a vacuum tube containing sodium fluoride from all eligible participants in the morning with at least 10 hours of overnight fasting. Serum samples were aliquoted. One sample for fasting plasma glucose (FPG) tested within 12 hours after collection in an accredited laboratory using glucose oxidase or hexokinase methods. Other samples were frozen at − 80 °C within 2 hours of collection and transported in dry ice to the central laboratory in Jiangsu Province Center for Disease Control and Prevention, which was certificated by the National Laboratory Certification of China. Serum Total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), and triglycerides (TG) were measured using auto-analysers (Abbott Laboratories).

Statistical analysis

Measurement of the risk of CVD

The assessment of CVD risk should be performed for all adults who are not known to have CVD or to be at clinically determined high risk. In this study, we used the Framingham Risk Score (FRS), which is expressed as a percentage, to estimate a person's chance of having a CVD event in the next ten years. The calculation of FRS is based on the prediction equation known as the 'Framingham Risk Equation' consisting of age, TC, HDL-C, SBP, treatment for hypertension, smoking, and diabetic status [19]. This equation has been tested for its validity and has shown to have good predictive ability.

The risk of CVD was defined as 'low' if the FRS ≤ 10%, 'intermediate' if the FRS was between 11% and 20%, and 'high' if the FRS > 20% [24].

Classification of physical activity

In this study, the physical activity of participants was classified using the LCA, an analysis method established on the basis of probability distribution and log-linear model. Researchers can explain the relationship between the investigated categorical variables (i.e., the risk of CVD for this study) through lesser potential categorical variables.

The model of LCA can be judged by the following test standards [25]:

(1) Akaike information criterion (AIC), Bayesian information criterion (BIC), and adjusted Bayesian information criterion (aBIC). The smaller the three indexes, the better the model fitting effect.

(2) Entropy, the larger the value, the higher the accuracy of the classification;

(3) In combination with the adjusted of the Lo-Mendell-Rubin likelihood ratio test (LMR) and the bootstrap-based likelihood ratio test (BLRT), The model of K categories is significantly better than the model of K-1 categories while $P < 0.05$ of these two indicators.

The (potentially) best classification can be determined based on above indicators, with relevant professional knowledge to be used for results interpretation.

Definitions of other involved variables

BMI was calculated as body weight (in kg)/height^2 (in meter), based on which individuals were categorized as: underweight (BMI < 18.5 kg/m^2), normal (18.50≤BMI < 24.00 kg/m^2), overweight (24.00≤BMI < 28.00 kg/m^2), and obesity (BMI ≥ 28.00 kg/m^2) according to the unified standard of the working group on obesity in China [26]: Central obesity refers to male waist circumference ≥ 90 cm and female waist circumference ≥ 85 cm [27].

Hypertension was defined as the systolic blood pressure (SBP) ≥ 140 mmHg and/or the diastolic blood pressure (DBP) ≥ 90 mmHg, or the respondents reported a history of hypertension or was taking antihypertensive drugs during the study period [28].

Diabetes mellitus are defined as FPG ≥ 7.0 mmol/L or OGTT ≥ 11.11 mmol/L, or the respondents report a history of diabetes or *was* taking hypoglycemic drugs during the study period [29]. An individual with high TC (TC ≥ 6.22 mmol/L) and/or high TG (TG ≥ 2.26 mmol/L) and/or low HDL-C (HDL-C < 1.04 mmol/L), and/or high LDL-C (LDL-C ≥ 4.14 mmol/L) [30] was categorized as dyslipidemia.

Current smoking was defined as having smoked 100 cigarettes in one's lifetime and currently smoking cigarettes; current drinking was defined as alcohol intake more than once per month during the past 12months [17].

General descriptive analysis and χ^2test were analyzed using the SPSS (v23.0) statistical software. MPLUS (v8.0) statistical software was used to analyze the potential categories (Latent Classes) of physical activity. The effects of Latent Classes on the risk of CVD were analyzed by ordered Logistic regression. Taking into account the fact that age, blood pressure, smoking status and other factors are included in the calculation of the FRS, Logistic regression analysis does not adjust for these variables. P value < 0.05 two-sides was considered as statistically significant.

Ethics approval and consent to participate

Informed consents were written by all participants. The procedures were in accordance with the standards of the ethics committee of Jiangsu Provincial Center for Disease Control and Prevention, and with the Declaration of Helsinki (1975, revised 2013). This study protocol was approved by the ethical review committee at the Jiangsu Province Center for Disease Control and Prevention (the committee's reference number: **SL2017-B002-01**). Individual person's data have not contained in any form (including any individual details, images or videos) in this manuscript.

Result

Characteristics of participants

The mean age of participants (men, 43.0%) was 52.04 years (SD = 11.08). Compared with females, males were more likely to have higher education, with a job, currently smoke, currently drink alcohol and with hypertension, while females were more likely to have central obesity and dyslipidemia (see Table 1).

Table 1
Characteristics of the study population by genders

	Categories	Number	female[n(%)]	male[n(%)]	χ²	*P*
Age(years)	≤ 34	196	113(5.6)	83(5.4)	25.770	< 0.001
	35 ~ 44	835	521(25.6)	314(20.5)		
	45 ~ 54	954	566(27.8)	388(25.3)		
	55 ~ 64	1038	559(27.5)	479(31.2)		
	≥ 65	545	275(13.5)	270(17.6)		
Education	Primary or below	1999	1333(65.5)	666(56.0)	173.690	< 0.001
	Middle	1414	631(31.0)	783(51.0)		
	High school or above	155	70(3.4)	85(5.5)		
BMI (kg/m^2)	≤ 18.49	57	30(1.5)	27(1.8)	6.385	0.094
	18.50 ~ 23.99	1582	874(43.1)	708(46.3)		
	24.00 ~ 27.99	1366	788(38.8)	578(37.8)		
	≥ 28.00	552	337(16.6)	215(14.1)		
Employment	No	824	588(28.9)	236(15.4)	90.053	< 0.001
	Yes	2744	1446(71.1)	1298(84.6)		
Sleep duration	< 6 h/d	231	149(7.3)	82(5.3)	23.130	< 0.001
	6 ~ 8 h	2514	1369(67.3)	1145(74.7)		
	> 8 h	822	516(25.4)	306(20.0)		
Smoking	No	2596	1965(96.6)	631(41.4)	1359.899	< 0.001
	Not everyday	140	18(0.9)	122(8.0)		
	Everyday	832	51(2.5)	781(50.9)		
Alcohol drinking	No	2282	1742(85.6)	540(35.2)	1052.172	< 0.001
	30 days ago	274	130(6.4)	144(9.4)		
	Within 30 days	1012	162(8.0)	850(55.4)		
Overweight or obesity	No	1650	909(44.7)	741(48.3)	4.597	0.032
	Yes	1918	1125(55.3)	793(51.7)		
Central obesity	No	1651	881(43.3)	770(50.2)	16.659	< 0.001
	Yes	1917	1153(56.7)	764(49.8)		
Hypertension	No	1693	1044(51.3)	649(42.3)	28.532	< 0.001
	Yes	1875	990(48.7)	885(57.7)		
Diabetes	No	3240	1851(91.0)	1389(90.5)	0.217	0.641
	Yes	328	183(9.0)	145(9.5)		
Dyslipidemia	No	2276	1381(67.9)	895(58.3)	34.540	< 0.001
	Yes	1292	653(32.1)	639(41.7)		

Latent classes analysis of physical activity

In the LCA of physical activity, 10 variables in the GPAQ including high occupational PA, medium-low occupational PA, commuting PA, high leisure-time PA, medium-low leisure time PA, sedentary PA, TV PA, computer PA, reading PA, and sleeping PA. Five latent class models were fitted for both men and women eventually (Table 2). With the increasing of the number of model categories, Log-like hood (Log (L)), AIC, BIC, and aBIC all decrease constantly. According to the comprehensive consideration index of male LCA, when fitting to 4 category models, LMR = 0.680, indicating the best fitting degree of third category models. Similarly, the female LCA has the best fitting degree of third category models. The average attribution probability matrix of the potential categories shows that the average probability (column) of the survey objects (rows) in each category belongs to each potential category, which further indicates that the results of the classification model of the third potential categories are credible. According to the results of conditional probability distribution of each item in 3 categories of models of each gender (Fig. 1 and Fig. 2), the performance of Latent CLASS1 is high occupational PA, low sedentary PA; the performance of Latent CLASS2 is low occupational and high leisure-time PA; the performance of Latent CLASS3 is low leisure time PA, high sedentary PA. The males of these three classifications were 492 (32.1%), 414 (27.0%) and 628 (40.9%) respectively, while the females were 539 (26.5%), 288 (14.2%) and 1207 (59.3%) respectively.

Table 2
The fitting index of latent category model for different categories

Model	df	Log(L)	AIC	BIC	aBIC	Entropy	LMR	BLRT	Class probability
Male									
1	11	-7984.588	15991.176	16049.868	16014.924				
2	23	-7684.239	15414.478	15537.197	15464.132	0.696	0.000	0.000	0.265/0.735
3	35	-7636.682	15343.363	15530.111	15418.924	0.547	0.004	0.000	0.270/0.409/0.321
4	47	-7602.892	15299.784	15550.559	15401.252	0.599	0.680	0.000	0.321/0.129/0.375/0.175
5	59	-7574.504	15267.008	15581.811	15394.383	0.650	0.011	0.000	0.062/0.130/0.397/0.118/0.293
Female									
1	11	-8964.428	17950.856	18012.652	17977.704				
2	23	-8637.917	17321.834	17451.042	17377.970	0.797	0.000	0.000	0.149/0.851
3	35	-8543.263	17156.526	17353.147	17241.950	0.614	0.000	0.000	0.265/0.593/0.142
4	47	-8505.732	17105.463	17369.498	17220.176	0.672	0.024	0.000	0.102/0.221/0.542/0.135
5	59	-8481.928	17081.857	17413.305	17225.858	0.560	0.184	0.000	0.481/0.227/0.150/0.028/0.115

Comparison of baseline characteristic distribution in different Latent Classes (CLASS1 to CLASS3)

Baseline characteristics of all initially participants are given by classifications in Tables 3 and 4. The classifications of PA for male in three Latent Classes were statistically significant in age, education status, marital status, BMI, employment status, sleep status, and smoking status ($P < 0.001$). They also have significant differences in low HDL-C, high TG, hypertension, hyperglycemia and central obesity ($P < 0.05$).

The classifications of PA for female in three Latent Classes were statistically significant in age, education status, marital status, BMI, employment status, sleep status, alcohol consumption, high TG, low HDL-C, Hypertension and Central obesity ($P < 0.01$).

Table 3
Comparison of the distribution of characteristics among different potential categories of male

	Categories	N	CLASS1(%)	CLASS2(%)	CLASS3(%)	χ^2	*P*
Age(years)	18 ~ 34	83	22(26.5)	38(45.8)	23(27.7)	111.911	< 0.001
	35 ~ 44	314	84(26.8)	133(42.4)	97(30.9)		
	45 ~ 54	388	142(36.6)	106(27.3)	140(36.1)		
	55 ~ 64	479	183(38.2)	83(17.3)	213(44.5)		
	≥ 65	270	61(22.6)	54(20.0)	155(57.4)		
Education status	Primary school or below	666	264(39.6)	55(8.3)	347(52.1)	337.152	< 0.001
	Middle school	783	226(28.9)	280(35.8)	277(35.4)		
	High school or above	85	2(2.4)	79(92.9)	4(4.7)		
Marital status	Married	1383	450(32.5)	389(28.1)	544(39.3)	16.530	< 0.001
		151	42(27.8)	25(16.6)	84(55.6)		
BMI(kg·cm^{-2})	≤ 18.49	27	8(29.6)	9(33.3)	10(37.0)	48.892	< 0.001
	18.50 ~ 23.99	708	240(33.9)	136(19.2)	332(46.9)		
	24.00 ~ 27.99	578	181(31.3)	182(31.5)	215(37.2)		
	≥ 28.00	215	62(28.8)	86(40.0)	67(31.2)		
Occupation	No	236	49(20.8)	90(38.1)	97(41.1)	23.968	< 0.001
	Yes	1298	443(34.1)	324(25.0)	531(40.9)		
Sleep state	< 6 h	82	19(23.2)	9(11.0)	54(65.9)	50.030	< 0.001
	6 ~ 8 h	1146	336(29.3)	333(29.1)	477(41.6)		
	> 8 h	306	137(44.8)	72(23.5)	97(31.7)		
Smoking	No	631	200(31.7)	182(28.8)	249(39.5)	24.172	< 0.001
	Not everyday	122	36(29.5)	52(42.6)	34(27.9)		
	Everyday	781	256(32.8)	180(23.0)	345(44.2)		
Alcohol drinking	No	540	169(31.3)	126(23.3)	245(45.4)	8.497	0.075
	In 30 days ago	144	49(34.0)	40(27.8)	55(38.2)		
	Within 30 days	850	274(32.2)	248(29.2)	328(38.6)		
High TC	Yes	63	20(4.1)	24(5.8)	19(3.0)	4.87	0.088
	No	1471	472(95.9)	390(94.2)	609(97.0)		
High TG	Yes	262	73(14.8)	92(22.2)	97(15.4)	10.661	0.005
	No	1272	419(85.2)	322(77.8)	531(84.6)		
Low HDL-C	Yes	430	115(23.4)	149(36.0)	166(26.4)	19.085	< 0.001
	No	1104	377(76.6)	265(64.0)	462(73.6)		
High LDL-C	Yes	24	6(1.2)	8(1.9)	10(1.6)	0.747	0.688
	No	1510	486(98.8)	406(98.1)	618(98.4)		
Hypertension	Yes	885	265(53.9)	230(55.6)	390(62.1)	8.735	0.013
	No	649	227(46.1)	184(44.4)	238(37.9)		
Hyperglycemia	Yes	145	46(9.3)	51(12.3)	48(7.6)	6.382	0.041
	No	1389	446(90.7)	363(87.7)	580(92.4)		
Central obesity	Yes	764	213(43.3)	258(62.3)	293(46.7)	36.77	< 0.001
	No	770	279(56.7)	156(37.7)	335(53.3)		

Table 4
Comparison of the distribution of characteristics among different potential categories of female

	Group	N	CLASS1(%)	CLASS2(%)	CLASS3(%)	χ^2	*P*
Age(years)	18 ~ 34	113	14(12.4)	51(45.1)	48(42.5)	190.908	< 0.001
	35 ~ 44	521	108(20.7)	120(23.0)	293(56.2)		
	45 ~ 54	566	140(24.7)	70(12.4)	356(62.9)		
	55 ~ 64	559	191(34.2)	38(6.8)	330(59.0)		
	≥ 65	275	86(31.3)	9(3.3)	180(65.5)		
Education status	Primary school or below	1333	417(31.3)	29(2.2)	887(66.5)	587.770	< 0.001
	Middle school	631	115(18.2)	202(32.0)	314(49.8)		
	High school or above	70	7(10.0)	57(81.4)	6(8.6)		
Marital status	Married	1805	460(25.5)	269(14.9)	1076(59.6)	12.692	0.002
		229	79(34.5)	19(8.3)	131(57.2)		
BMI (kg·cm^{-2})	≤ 18.49	30	4(13.3)	3(10.0)	23(76.7)	21.571	0.001
	18.50 ~ 23.99	874	237(27.1)	154(17.6)	483(55.3)		
	24.00 ~ 27.99	788	207(26.3)	94(11.9)	487(61.8)		
	≥ 28.00	337	90(26.7)	35(10.4)	212(62.9)		
Occupation	No	588	156(26.5)	112(19.0)	320(54.4)	19.332	< 0.001
	Yes	1446	383(26.5)	176(12.2)	887(61.3)		
Sleep state	< 6 h	149	37(24.8)	4(2.7)	108(72.5)	86.996	< 0.001
	6 ~ 8 h	1369	301(22.0)	241(17.6)	827(60.4)		
	> 8 h	516	201(39.0)	43(8.3)	272(52.7)		
Smoking	No	1965	526(26.8)	283(14.4)	1156(58.8)	6.701	0.153
	Not everyday	18	3(16.7)	1(5.6)	14(77.8)		
	Everyday	51	10(19.6)	4(7.8)	37(72.5)		
Alcohol drinking	No	1742	458(26.3)	204(11.7)	1080(62.0)	66.394	< 0.001
	In 30 days ago	130	38(29.2)	38(29.2)	54(41.5)		
	Within 30 days	162	43(26.5)	46(28.4)	73(45.1)		
High TC	Yes	70	17(3.2)	9(3.1)	44(3.6)	0.372	0.83
	No	1964	522(96.8)	279(96.9)	1163(96.4)		
High TG	Yes	266	71(13.2)	18(6.3)	177(14.7)	14.488	0.001
	No	1768	468(86.8)	270(93.8)	1030(85.3)		
Low HDL-C	Yes	362	68(12.6)	70(24.3)	224(18.6)	18.707	< 0.001
	No	1672	471(87.4)	218(75.7)	983(81.4)		
High LDL-C	Yes	27	9(1.7)	3(1.0)	15(1.2)	0.728	0.695
	No	1007	530(98.3)	285(99.0)	1192(98.8)		
Hypertension	Yes	990	302(56.0)	76(26.4)	612(50.7)	70.917	< 0.001
	No	1044	237(44.0)	212(73.6)	595(49.3)		
Hyperglycemia	Yes	183	50(9.3)	23(8.0)	110(9.1)	0.431	0.806
	No	1851	489(90.7)	265(92.0)	1097(90.9)		
Central obesity	Yes	1153	306(56.8)	122(10.6)	725(60.1)	29.688	< 0.001
	No	881	233(43.2)	166(57.6)	482(39.9)		

Associations of physical activity and the risk of CVD

Comparisons of the Framingham 10-year CVD risks core between the classifications in male revealed statistically significant differences. As presented in Table 5, the FRSs of male were always higher than that of female. Compared to membership in CLASS3, the FRS for CLASS1 and CLASS2 were lower than that of CLASS3, which had the largest number of people. CLASS1 (OR = 0.654,95%CI: 0.526–0.813) and CLASS2 (OR = 0.544, 95%CI: 0.432–0.685) were protective factors for CVD compared to CLASS3. These differences remained in the fully adjusted models, the CLASS1 (OR = 0.694, 95%CI: 0.553–0.869) and CLASS2(OR = 0.748, 95%CI: 0.573–0.976) were also the protective factors for CVD.

In female, compared to CLASS3, CLASS2 was a protective factor for CVD (OR = 0.451, 95%CI: 0.316–0.643), nevertheless, no significant differences were found in the adjusted model.

Table 5
FRS among different categories of latent classes and associations of physical activity and the risk of CVD

Latent class	**N**	**`χ ± σ(%)**	**Crude**		**Adjusted***	
			P	**OR(95%*CI*)**	*P*	**OR(95%*CI*)**
Male	1534					
CLASS1	492	17.42 ± 14.47	0.000	0.654(0.526–0.813)	0.002	0.694(0.553–0.869)
CLASS2	414	17.14 ± 16.18	0.000	0.544(0.432–0.685)	0.032	0.748(0.573–0.976)
CLASS3	628	21.12 ± 16.06	Ref.			
Female	2034					
CLASS1	539	8.25 ± 8.34	0.683	1.048(0.836–1.314)	0.732	1.042(0.823–1.319)
CLASS2	288	5.32 ± 7.64	0.000	0.451(0.316–0.643)	0.607	0.896(0.588–1.363)
CLASS3	1207	8.67 ± 10.14	Ref.			

Note: *adjusted for education, employment status, drinking, BMI, dyslipidemia, central obesity and overweight/obesity

Discussion

Millions of people across the world struggle to control the risk factors that lead to CVD, many others remain unaware that they are at high risk, a large number of heart attacks and strokes can be prevented by controlling major risk factors through lifestyle interventions and drug treatment where necessary [4]. The risk factors for CVD include behavioral factors, such as tobacco use, unhealthy diet and inadequate physical activity [4], which could be used to assess the risk of CVD and identify major behavior patterns associated with CVD.

The China Kadoorie Biobank (CKB) study [31] reported that total physical activity [32] was strongly and inversely associated with CVD mortality. People have gradually changed from a labor-intensive lifestyle to a sedentary lifestyle, with both occupational and leisure physical activities decreased in recent decades among Chinese people [1]. A prospective cohort study of 487,334 subjects conducted by Bennett et al [7] in 10 regions of China showed that higher occupational or nonoccupational PA was significantly associated with lower risk of major CVD among Chinese adults.

Through the PCA of participants' PA, this study found that it could be summarized as three groups of different PA types (Latent Classes): CLASS1 (high occupational and low sedentary PA), CLASS2 (low occupational and high leisure-time PA) and CLASS3 (low leisure-time and high sedentary PA). Several previous LCA studies provided limited and varied findings in different fields, such as sociology, biology, medicine and psychology[33]. To our knowledge, our study is one of the first studies to identify associations between CVD and PA among Chinese adults using LCA with representative data.

This study showed that CLASS3, i.e. people with low levels of PA, accounted for a big proportion in the three categories (40.9% for males and 59.3% for females). As can be seen, the main PA behavior of CLASS3 is manifested as high sedentary and low leisure-time activity behavior generally. A survey of nine provinces in China from 1991 to 2011[34] found that for both adult men and women in China, occupational and domestic PA were by far the largest contributors to PA, the residents' overall PA was significantly decline and active leisure and travel PA were both low. Quite a few studies in China such as have also shown that the occupational PA was the most widespread PA in Chinese residents currently, while the leisure PA was reversely low [35, 36]. Inadequate physical inactivity has become one of the major risk factors for CVD death and disease burden in China [37].

This study explored the differences in the 10-year risk of CVD among the three types of PA predicted by the Framingham risk scoring system. The results showed that the 10-year risk of CVD in male was 2 to 3 times higher than that in female in all three categories. Previous studies [38, 39] indicated that male generally had a higher risk to develop CVD events, which may be related to differences in exposure levels and sensitivities of risk factors for CVD between genders, in addition to sex hormone differences. Both gender showed CLASS3 CVD risk higher than that of both CLASS1 and CLASS2, after the adjustment of confounding factors, found that the risk of CVD in CLASS3 in males was 1.44, 1.34 times compared to CLASS1 and CLASS2.This result is consistent with Petagna's [40] adult health longitudinal study and Li's [9] Meta-analysis consisting of 21 prospective studies involving 20000 patients with CVD definitely. As a result, the 2018 PA guidelines for Americans [41] emphasize that increasing PA and reducing sedentary time are appropriate for all populations, and that even a little increase in PA can bring health benefits. According to the American college of sports medicine (ACSM) [42], regular PA (such as exercise, cycling, etc.), may reduce insulin levels and renal sympathetic nerve tension by sodium retention and foundation, vasodilator substances by skeletal muscle release cycle, and can improve blood pressure, blood lipid and blood glucose and other risk factors [43].

The method of the LCA takes account the comprehensive effect of multiple factors, can reveal the characteristics of various groups of people and provide scientific basis for the designation of targeted intervention and prevention measures. However, several limitations of the study should be considered. First of all, the LCA takes the qualitative data into consideration, instead of the comprehensive analysis of its frequency and duration. Secondly, using the method of questionnaire survey to collect physical activity information, rather than using objective measurements (e.g. using pedometers to calculate the exact daily steps), may lead to recall bias. Nevertheless, the use of a tool with proven validity and reliability, i.e. the GPAQ, together with adequate staff training, can minimise such bias. Limited by a cross-sectional design of the study, it is hardly to explain the causal relationship of PA and the risk of CVD and further robustly designed longitudinal research are warranted to test this relationship.

To summarize, the study reveals potential associations between CVD and PA patterns among Chinese adults, with the lower occupational and leisure-time PA and higher sedentary PA related to increased risk of CVD. Accordingly, we suggest relevant sectors in China strengthening evidence-based interventions in order to increase PA and reduce the time of sedentary behaviors. Findings from this study can bring contributions to public health, particularly in the management of public policies that promote PA and bring more health benefits.

Abbreviations

CVD
cardiovascular diseases
PA
physical activity
LCA
latent class analysis
FRS
Framingham risk score
LCM
latent class model
PTSD
posttraumatic stress disorder
GPAQ
Global Physical Activity Questionnaire
FPG
fasting plasma glucose
TC
serum Total cholesterol
LDL-C
low-density lipoprotein cholesterol
HDL-C
high-density lipoprotein cholesterol
TG
triglycerides
AIC
Akaike information criterion
BIC
Bayesian information criterion
aBIC
adjusted Bayesian information criterion
LMR
Lo-Mendell-Rubin likelihood ratio test
BLRT
bootstrap-based likelihood ratio test
SBP
systolic blood pressure
DBP
diastolic blood pressure
Log (L)
Log-like hood

CKB
China Kadoorie Biobank

Declarations

Ethics approval and consent to participate

This study protocol was approved by the ethical review committee of the Jiangsu Province Center for Disease Control and Prevention **(the committee's reference number: SL2017-B002-01).** In this manuscript, we have not contained any person's data in any form (including any individual details, images or videos). Written informed consent was obtained from all study participants.

Consent for publication

No conflict of interest exists in the submission of this manuscript, and the manuscript is approved by all authors for publication.

Availability of data and material

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Figures

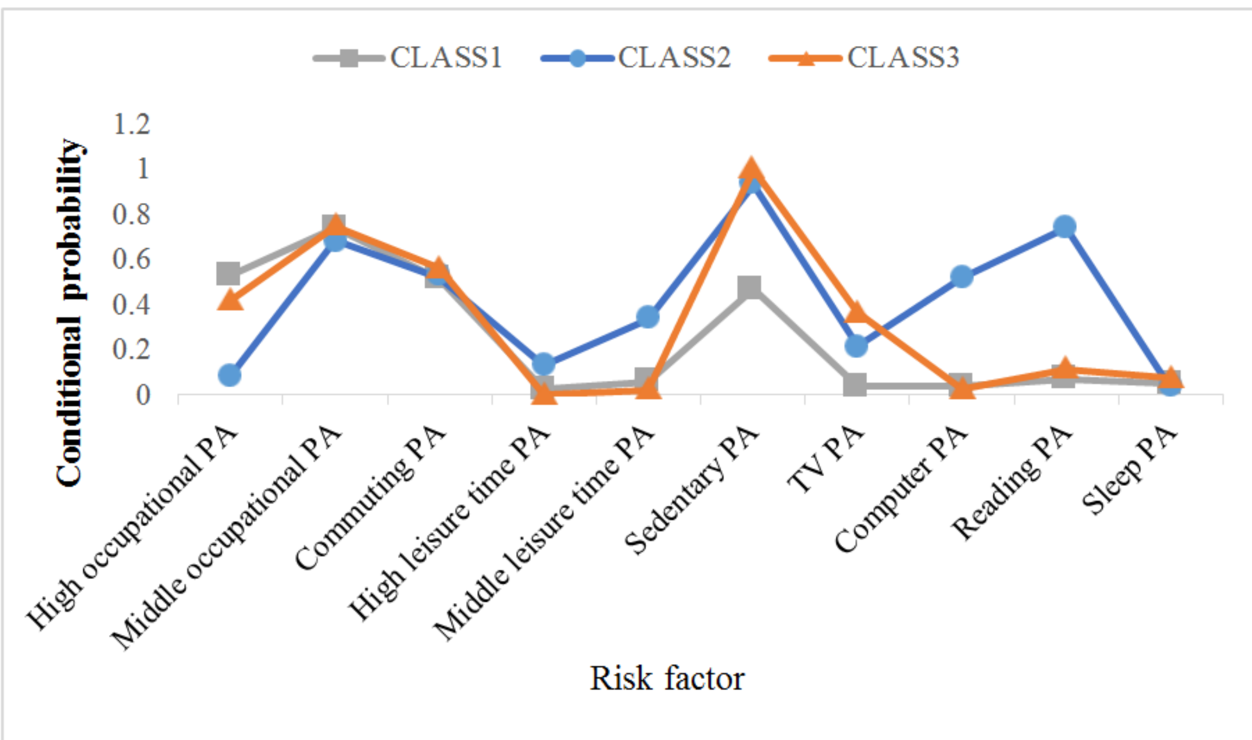

Figure 1

Conditional probability distribution for three categories of physical activity of male

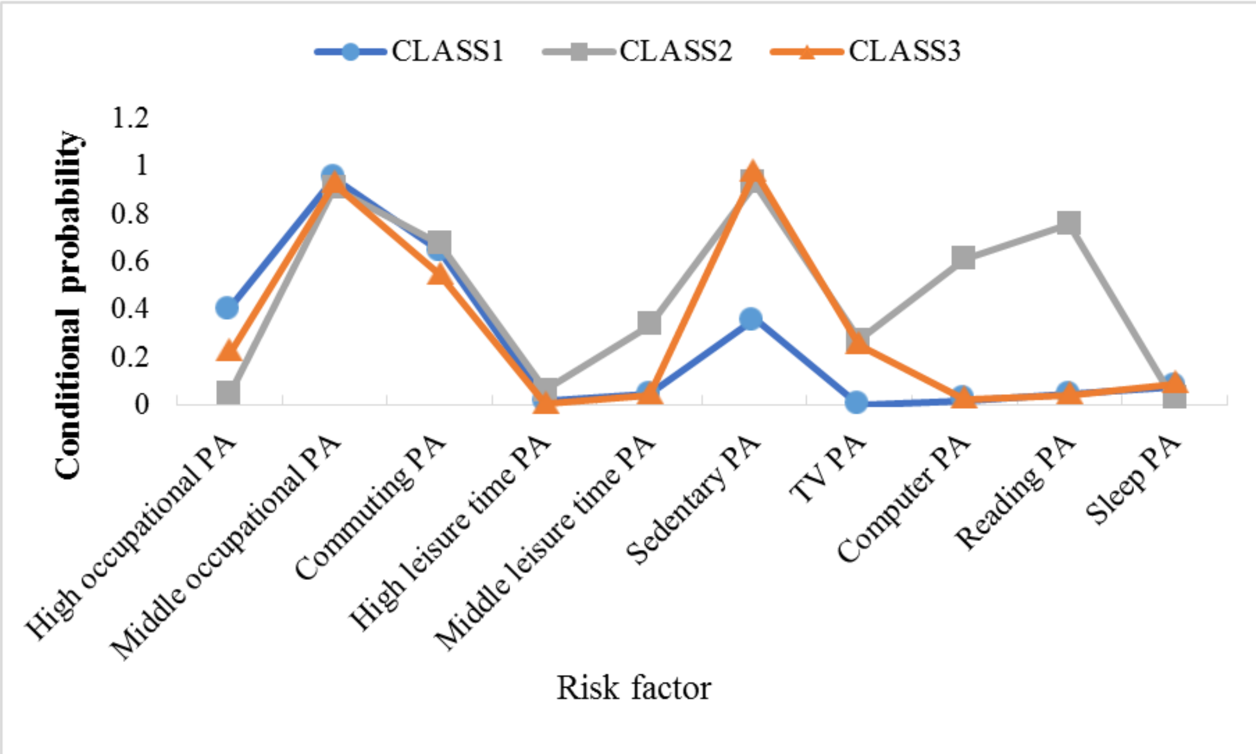

Figure 2

Conditional probability distribution for three categories of physical activity of female