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

Participants 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. 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 sphygmomanometers 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 $\leq$ BMI $< 24.00$ kg/m$^2$), overweight (24.00 $\leq$ BMI $< 28.00$ kg/m$^2$), and obesity (BMI $\geq 28.00$ kg/m$^2$) according to the unified standard of the working group on obesity in China [26]. Central obesity refers to male waist circumference $\geq 90$ cm and female waist circumference $\geq 85$ cm [27].

Hypertension was defined as the systolic blood pressure (SBP) $\geq 140$ mmHg and/or the diastolic blood pressure (DBP) $\geq 90$ 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 $\geq 7.0$ mmol/L or OGTT $\geq 11.11$ 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 $\geq 6.22$ mmol/L) and/or high TG (TG $\geq 2.26$ mmol/L) and/or low HDL-C (HDL-C $< 1.04$ mmol/L), and/or high LDL-C (LDL-C $\geq 4.14$ 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 12 months [17].

General descriptive analysis and $\chi^2$ test 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/m²)**             |        |              |            |      |         |
| ≤ 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.

| Model | df   | Log(L)    | AIC     | BIC     | aBIC   | Entropy | LMR | BLRT       | Class probability          |
|-------|------|-----------|---------|---------|--------|---------|-----|------------|----------------------------|
| Male  | 1    | -7984.588 | 15991.176 | 16049.868 | 16014.924 |        |     |            | 0.265/0.735               |
|       | 2    | -7684.239 | 15414.478 | 15537.197 | 15464.132 | 0.696   | 0.000 | 0.000      |                             |
|       | 3    | -7636.682 | 15343.363 | 15530.111 | 15418.924 | 0.547   | 0.004 | 0.000      | 0.270/0.409/0.321          |
|       | 4    | -7602.892 | 15299.784 | 15530.111 | 15401.252 | 0.599   | 0.680 | 0.000      | 0.321/0.129/0.375/0.175    |
|       | 5    | -7574.504 | 15267.008 | 15581.811 | 15394.383 | 0.650   | 0.011 | 0.000      | 0.062/0.130/0.397/0.118/0.293|
|       | 1    | -8964.428 | 17950.856 | 18012.652 | 17977.704 |        |     |            | 0.149/0.851               |
|       | 2    | -8637.917 | 17321.834 | 17451.042 | 17377.970 | 0.797   | 0.000 | 0.000      |                             |
|       | 3    | -8543.263 | 17156.526 | 17353.147 | 17241.950 | 0.614   | 0.000 | 0.000      | 0.265/0.593/0.142          |
|       | 4    | -8505.732 | 17105.463 | 17369.498 | 17220.176 | 0.672   | 0.024 | 0.000      | 0.102/0.221/0.542/0.135    |
|       | 5    | -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(%) | χ² | 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) |    |       |
| Group               | N     | CLASS1(%) | CLASS2(%) | CLASS3(%) | χ²   | 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  | 522(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

| Latent class | N  | $\chi^2$ d.f. (%) | Crude | Adjusted* |
|-------------|----|------------------|-------|-----------|
|             |    |                  |       |           |
| Male        |    |                  |       |           |
| 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) | 0.036 | 0.748(0.573–0.976) |
| CLASS3      | 628| 21.12 ± 16.06    | Ref.  |           |       |                   |
| Female      |    |                  |       |           |
| 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) | 0.007 | 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
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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References

1. Cheng X, Li W, Guo J, Wang Y, Gu H, Teo K, Liu L, Yusuf S, Investigators ICs. Physical activity levels, sport activities, and risk of acute myocardial infarction: results of the INTERHEART study in China. Angiology 2014, 65(2):113-121.

2. Shortreed SM, Peeters A, Forbes AB. Estimating the effect of long-term physical activity on cardiovascular disease and mortality: evidence from the Framingham Heart Study. Heart 2013, 99(9):649-654.

3. Centers for Disease Control and Prevention. Physical activity and health. [https://www.cdc.gov/physicalactivity/basics/pa-health/index.htm#ReducedCancer.]

4. World Health Organization (WHO). Cardiovascular diseases. [https://www.cdc.gov/physicalactivity/basics/pa-health/index.htm#ReducedCancer.]

5. He J, Gu D, Wu X, Reynolds K, Duan X, Yao C, Wang J, Chen CS, Chen J, Wildman RP et al. Major causes of death among men and women in China. N Engl J Med 2005, 353(11):1124-1134.

6. Hu SS, Gao RL, Liu LS, Zhu ML, Wang W, Wang YJ, Wu ZS, Li HJ, Gu DF, Yang YJ et al. Summary of the 2018 Report on Cardiovascular Diseases in China. Chinese Circulation Journal 2019, 34(3):209-220.

7. Bennett DA, Du H, Clarke R, Guo Y, Yang L, Bian Z, Chen Y, Millwood I, Yu C, He P et al. Association of Physical Activity With Risk of Major Cardiovascular Diseases in Chinese Men and Women. JAMA Cardiol 2017, 2(12):1349-1358.
8. GBD 2017 Risk Factor Collaborators: Global, regional, and national comparative risk assessment of 84 behavioural, environmental and occupational, and metabolic risks or clusters of risks for 195 countries and territories, 1990-2017: a systematic analysis for the Global Burden of Disease Study 2017. Lancet 2018, 392(10159):1923-1944.

9. Li J, Siegrist J: Physical activity and risk of cardiovascular disease–a meta-analysis of prospective cohort studies. Int J Environ Res Public Health 2012, 9(2):391-407.

10. Du H, Bennett D, Li L, Whitlock G, Guo Y, Collins R, Chen J, Bian Z, Hong LS, Feng S et al: Physical activity and sedentary leisure time and their associations with BMI, waist circumference, and percentage body fat in 0.5 million adults: the China Kadoorie Biobank study. Am J Clin Nutr 2013, 97(3):487-496.

11. Zeng XH, Xiao L, Zhang YB: Principle and case analysis of latent class analysis. Chinese Journal of Health Statistics 2013, 30(6):815-817.

12. Kongsted A, Nielsen AM: Latent Class Analysis In health research. J Physiother 2017, 63(1):55-58.

13. Vermunt JK, Magidson J: Latent Class Cluster Analysis. In: Applied Latent Class Analysis, edn.; 2002: 89-106.

14. Miranda VPN, Dos Santos Amorim PR, Bastos RR, Souza VGB, de Faria ER, do Carmo Castro Franceschini S, Priore SE: Evaluation of lifestyle of female adolescents through latent class analysis approach. BMC Public Health 2019, 19(1):184.

15. Breslau N, Reboissiu BA, Anthony JC, Storr CL: The structure of posttraumatic stress disorder: latent class analysis in 2 community samples. Arch Gen Psychiatry 2005, 62(12):1343-1351.

16. Logan J, Hall J, Karch D: Suicide categories by patterns of known risk factors: a latent class analysis. Arch Gen Psychiatry 2011, 68(9):935-941.

17. Xu Y, Wang L, He J, Bi Y, Li M, Wang T, Wang L, Jiang Y, Dai M, Lu J et al: Prevalence and control of diabetes in Chinese adults. JAMA 2013, 310(9):948-959.

18. Kish L: A Procedure for Objective Respondent Selection within the Household. Journal of the American Statistical Association 1949, 44(247):380-387.

19. D’Agostino RB, Sr., Vasan RS, Pencina MJ, Wolf PA, Cobain M, Massaro JM, Kannel WB: General cardiovascular risk profile for use in primary care: the Framingham Heart Study. Circulation 2008, 117(6):743-753.

20. Armstrong T, Bull F: Development of the World Health Organization Global Physical Activity Questionnaire (GPAQ). Journal of Public Health 2006, 14(2):66-70.

21. Cleland CL, Hunter RF, Kee F, Cupples ME, Sallis JF, Tully MA: Validity of the global physical activity questionnaire (GPAQ) in assessing levels and change in moderate-vigorous physical activity and sedentary behaviour. BMC Public Health 2014, 14:1255.

22. Bloomfield GS, Mwangi A, Chege P, Simiyu CJ, Aswa DF, Odhiambo D, Obala AA, Ayuo P, Khwa-Otsyula BO: Multiple cardiovascular risk factors in Kenya: evidence from a health and demographic surveillance system using the WHO STEPwise approach to chronic disease risk factor surveillance. Heart 2013, 99(18):1323-1329.

23. Lyu S, Su J, Xiang Q, Wu M: Association of dietary pattern and physical activity level with triglyceride to high-density lipoprotein cholesterol ratio among adults in Jiangsu, China: a cross-sectional study with sex-specific differences. Nutr Res 2014, 34(8):674-681.

24. Ridker PM, Buring JE, Rifai N, Cook NR: Development and validation of improved algorithms for the assessment of global cardiovascular risk in women: the Reynolds Risk Score. JAMA 2007, 297(6):611-619.

25. Li DD, Han N, Cui Z, Li CP, Liu YY, Ma J: Application of latent class model in the classification of the patients with diabetes vulnerability. Chinese Journal of Health Statistics 2018, 35:11-13,17.

26. Chen W, Jiang H: Interpretation of the consensus of Chinese experts on nutritional medical treatment for overweight / obesity in 2016. Chinese Journal of Practical Internal Medicine 2017, 24(1):24-56.

27. Tian Y, Yang SC, Yu CQ, Guo Y, Bian Z, Tan YL, Pei P, Chen JS, Chen ZM, Lv Y et al: A prospective study of the risk of central obesity and ischemic heart disease in Chinese adults. Chin J Hypertens 2019, 27:300.

28. Writing Group of 2018 Chinese Guidelines for the Management of Hypertension, Chinese Hypertension League, Chinese Society of Cardiology, Chinese Medical Doctor Association Hypertension Committee, Hypertension Branch of China International Exchange and Promotive Association for Medical and Health Care, Associatio HBoCGM: 2018 Chinese guidelines for the management of hypertension. Chin J Cardiovasc Med 2019, 24(01):24-56.

29. Chinese Diabetes Society: Guidelines for the prevention and control of type 2 diabetes in China (2017 Edition). In: Chinese Journal of Practical Internal Medicine. vol. 38; 2018: 292-344.

30. Joint committee for guideline revision: 2016 Chinese guidelines for the management of dyslipidemia in adults. J Geriatr Cardiol 2018, 15(1):1-29.

31. Chen Z, Chen J, Collins R, Guo Y, Peto R, Wu F, Li L, China Kadoorie Biobank Collaborative Group: China Kadoorie Biobank of 0.5 million people: survey methods, baseline characteristics and long-term follow-up. Int J Epidemiol 2011, 40(6):1652-1666.

32. Sadarangani KP, Hamer M, Mindell JS, Coombs NA, Stamatakis E: Physical activity and risk of all-cause and cardiovascular disease mortality in diabetic adults from Great Britain: pooled analysis of 10 population-based cohorts. Diabetes Care 2014, 37(4):1016-1023.

33. Tsai J, Harpaz-Rotem I, Pilver CE, Wolf EJ, Hoff RA, Levy KN, Sareen J, Pietrzak RH: Latent class analysis of personality disorders in adults with posttraumatic stress disorder: results from the National Epidemiologic Survey on Alcohol and Related Conditions. J Clin Psychiatry 2014, 75(3):276-284.
34. Ng SW, Howard AG, Wang HJ, Su C, Zhang B: The physical activity transition among adults in China: 1991-2011. Obes Rev 2014, 15 Suppl 1:27-36.
35. Ding XB: Study on the correlation between physical activity and chronic diseases among residents in Chongqing. Modern Preventive Medicine 2016, 43(16):2992-2996.
36. Ma FC, Zhou MR, Yue JN, Sha QY, Zhou SX, Guo SL: Relationship between the physical activity level and non-communicable chronic diseases among adult residents in Qinghai province. Chin J Prev Contr Chron Dis 2016, 24(7):481-484.
37. Institute for Health Metrics and Evaluation (IHME): GBD compare data visualization [EB/OL] [http://vizhub.healthdata.org/gbd-compare]
38. Farhangi MA, Jahangiry L: Gender difference in the association between Framingham Risk Score with cardio-metabolic risk factors and psychological distress in patients with metabolic syndrome. Diabetes Metab Syndr 2020, 14(2):71-75.
39. Borhanuddin B, Mohd Nawi A, Shah SA, Abdullah N, Syed Zakaria SZ, Kamaruddin MA, Velu CS, Ismail N, Abdullah MS, Ahmad Kamat S et al. 10-Year Cardiovascular Disease Risk Estimation Based on Lipid Profile-Based and BMI-Based Framingham Risk Scores across Multiple Sociodemographic Characteristics: The Malaysian Cohort Project. ScientificWorldJournal 2018, 2018:2979206.
40. Pitanga FJG, Matos SMA, Almeida MDC, Barreto SM, Aquino EML: Leisure-Time Physical Activity, but not Commuting Physical Activity, is Associated with Cardiovascular Risk among ELSA-Brasil Participants. Arq Bras Cardiol 2018, 110(1):36-43.
41. Piercy KL, Troiano RP, Ballard RM, Carlson SA, Fulton JE, Galuska DA, George SM, Olson RD: The Physical Activity Guidelines for Americans. JAMA 2018, 320(19):2020-2028.
42. American College of Sports Medicine. Position Stand. Physical activity, physical fitness, and hypertension. Medicine and science in sports and exercise 1993, 25.
43. The Joint Task Force for Guideline on the Assessment and Management of Cardiovascular Risk in China: Guideline on the Assessment and Management of Cardiovascular Risk in China. Chinese Circulation Journal 2019, 34(1).

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