Excessive physical activity duration may be a risk factor for hypertension in young and middle-aged populations

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Abstract
Physical inactivity is known to cause many health problems globally each year. However, evidence regarding the interaction between excessive physical activity (PA) and blood pressure in young and middle-aged populations is limited.

A multistage, stratified, random-cluster sampling design was adopted to recruit representative samples. Participants were asked to complete a questionnaire and undergo physical examinations. Associations between prehypertension, hypertension and PA durations were examined by multivariable logistic regression.

Overall, 8206 subjects (4110 men, 50.1%) aged 15 to 45 years were enrolled. The prevalence rates of prehypertension and hypertension were 45.7% and 5.0%, respectively. Among the 1913 participants who performed moderate-intensity PA for more than 700 min/wk, 118 had hypertension (6.2%) and 845 had prehypertension (44.2%). Among the 1003 participants who performed vigorous-intensity PA for more than 450 min/wk, 82 had hypertension (8.2%) and 479 had prehypertension (47.8%).

Long-term and sustained PA may increase the risk for hypertension in young and middle-aged subjects. An appropriate recommendation of PA duration should be encouraged in this cohort.

Abbreviations: BF% = body fat percentage, BMI = body mass index, BP = blood pressure, CI = confidence intervals, CVD = cardiovascular diseases, dBP = diastolic blood pressure, HTN = hypertension, IPAQ = international physical activity questionnaire, MPA = moderate-intensity physical activity, NCDs = noncommunicable disease, PA = physical activity, pre-HTN = prehypertension, sBP = systolic blood pressure, SRS = simple random sampling, VPA = vigorous-intensity physical activity, WC = waist circumference, WHO = World Health Organization.

Keywords: blood pressure, Chinese population, duration and intensity of physical activity, young and middle-aged populations

1. Introduction
Regular physical activity (PA) improves noncommunicable diseases (NCDs) risk factors and reduces cardiovascular events.<sup>[1,2]</sup> Previous studies have indicated that PA can reduce the prevalence of cardiovascular diseases (CVD) by delaying the progression of prehypertension (pre-HTN).<sup>[3]</sup> For greater health benefits, frequent and sustained PA should be incorporated into daily life and gradually increased. However, other than the lower limit for PA duration during daily life,<sup>[4–8]</sup> no comprehensive studies have investigated the association between an excessive duration of PA duration and blood pressure (BP). Recently, certain health concerns related to performing PA out of range: chronic intense endurance exercise increases the internal diameters and wall thicknesses of the ventricles in the heart, the mass of the left ventricle, the volumes of the right and left ventricles, and the size of the left atrium.<sup>[9]</sup> Furthermore, previous studies have also indicated that excessive exercises such as marathon running actually increases arterial stiffness and can promote the progression of atherosclerosis.<sup>[10]</sup> Moreover, the prevalence of atrial fibrillation and other arrhythmias requiring treatment is known to be higher among individuals who participate in extreme exercise than among typical individuals.<sup>[9]</sup>

The aim of this study was to investigate the association between long-duration, high-intensity of PA and the prevalence of hypertension (HTN).

2. Methods
2.1. Study cohort
This study adopted a multistage, stratified, random-cluster sampling design. In the first stage, the probability proportional to size method was used to select 4 villages (rural) and 4 towns.
From the 21 villages and 19 towns in Chongqing, southwest China. In the second stage, 2 subdistricts (each referred to as a “street” in the urban regions and a “township” in the rural regions) were chosen from the selected towns and villages using the simple random sampling (SRS) method. In the third stage, 3 communities were randomly selected from each sub-district. In the final stage, a given number of participants from each of the gender/age strata were also selected using the SRS method. All the procedures were performed in accordance with ethical standards. This study was approved by the Ethics Committee of the First Affiliated Hospital of Chongqing Medical University. Written informed consent was obtained from all participants after they had been informed of the objectives of the study, as well as the benefits, medical items and confidentiality related to their personal information.\textsuperscript{111}

### 2.2. Study protocol and evaluation criteria

Multistage stratified sampling was performed, subjects were randomly included. During the visits, investigators administered a standard questionnaire to obtain demographic characteristics, including age, sex, education, alcohol consumption, and cigarette consumption. The participants also completed an international physical activity questionnaire (IPAQ) similar to a previously validated questionnaire and underwent physical examinations.\textsuperscript{12}

We defined individuals older than 15 years old and younger than 45 years old as the young and middle-aged populations.\textsuperscript{13}

Height was calculated to the nearest 0.1 cm using a calibrated scale and a vertical ruler with the participants wearing light clothing without shoes.

Weight was measured by an electronic body weightometer to the nearest 0.1 kg with the participants wearing light indoor clothing without shoes. Education was coded according to the International Standard Classification of Education (ISCED-97) (UNE-SCO1997).\textsuperscript{14} For the analyses, the subjects were divided into 2 groups:

1. A-level: secondary, second stage of basic education, and primary education, first stage of basic education or incomplete primary education; and
2. B-level: postsecondary, first or second stage of tertiary education.

Individuals with regular jobs were defined as incumbent; otherwise, individuals were assigned to the demission category. Individuals who reported smoking either in the past (including ex-smokers) or present were defined as smokers. Individuals who had a history of alcohol use either in the past (including ex-drinkers) or present were defined as alcohol drinkers.

The current World Health Organization (WHO) recommendation on sodium consumption for adults (≥16 years of age) less than 5 g/d is to avoid exercise and alcohol, cigarette, coffee, and tea consumption for at least 2 hours. An appropriately sized cuff was selected based on the circumference of the right upper arm of the participant. The average of the 3 readings was calculated and recorded. The classification of normotensive, prehypertensive and hypertensive patients was based on BP classifications outlined in the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC-7).\textsuperscript{15} Normal BP was defined as no use of antihypertensive medication and a systolic blood pressure (sBP) <120 mm Hg and diastolic blood pressure (dBP) <80 mm Hg. Pre-HTN was defined as no use of antihypertensive medication and a sBP of 120 to 139 mm Hg or dBP of 80 to 89 mm Hg. HTN was defined as a sBP ≥140 mm Hg or dBP ≥90 mm Hg or self-reported use of antihypertensive medications in the last 2 weeks, regardless of BP.\textsuperscript{16}

The IPAQ was developed with reference to the Typical Week Physical Activity Survey and assessed participation in activities from various domains during the past year, including household, transportation, occupation, and volunteer work; caring for others; leisure, recreation, and exercise; and stair climbing.\textsuperscript{20} For each item, the participants reported the number of hours per day spent participating in each activity on days when they engaged in that behavior in an open-ended format. According to the IPAQ, the total PA summary estimate reflects all 13 included activities or activity categories.\textsuperscript{20} Vigorous-intensity physical activity (VPA) includes

1. jogging or running,
2. strenuous racket sports,
3. bicycling faster than 10 mph or exercising intensively on an exercise bike,
4. swimming,
5. engaging in an intensive exercise class or dancing,
6. strenuous home or leisure activities (eg, shoveling snow, moving heavy objects, or weight lifting),
7. strenuous job activities (eg, lifting, carrying, or digging),
8. strenuous sports (eg, basketball, football, skating, or skiing).

Moderate-intensity physical activity (MPA) includes

1. nonstrenuous sports (eg, softball, shooting baskets, volleyball, ping pong, or leisurely jogging, swimming, or biking),
2. taking walks or hikes or walking to work,
3. bowing or golf,
4. home exercises or calisthenics,
5. home maintenance or gardening (painting, raking, or mowing).

PA in episodes of at least 10 minutes was recorded. More than 150 minutes of VPA per week, or more than 300 minutes of MPA per week for even greater health benefits, was defined as appropriate.\textsuperscript{16,17}
2.3. Statistical analysis

Statistical analyses were performed using SPSS 21.0 software (IBM, Armonk, NY). Descriptive analyses were conducted for demographic characteristics and risk factors. Continuous variables were summarized as the means with standard deviations or as the medians with interquartile ranges (with the range between the 25th and 75th percentiles) for data with a non-normal distribution, and categorical variables were expressed as counts and percentages, n (%). Differences between 2 groups were analyzed using Student t test for measurement data (continuous variables) and the chi-square test for enumeration data (categorical variables). To examine the exposure variable and its association with selected factors, we used multivariable logistic regression analysis with adjusting for sex, education level, BMI, occupational status, tobacco use, alcohol use, and salt intake. The results are presented as least squares means with 95% confidence intervals (CI). All statistical tests reported in this study were 2-sided, and P < .05 was considered statistically significant.

3. Results

The baseline characteristics of the subjects in the study stratified by area are shown in Table 1. Compared with rural participants, urban participants had significantly higher educational level, SBP, DBP, BMI, BF% values, and WC values.

Table 2 shows that 45.7% of the involved populations had pre-HTN and 5.0% suffered from HTN. The prevalence rates of HTN and pre-HTN were highest in the incumbent group and the demission group, respectively. The prevalence of pre-HTN was higher among rural residents than that among urban residents (51.6% vs 39.7%, P < .05). Men had a higher prevalence of pre-HTN than women (urban: 50.0% vs 29.2%, P < .05; rural: 54.9% vs 43.9%, P < .05) and HTN (urban: 6.8% vs 3.6%, P < .05; rural: 5.3% vs 4.4%, P < .05). In the 2 investigated regions, the prevalence of appropriate VPA was higher among men than among women (urban 30.6% vs 16.8%, P < .05; rural 28.2% vs 11.1%, P < .05). Meanwhile, nearly half of the cohort achieved the guidelines for MPA, with a higher prevalence of appropriate MPA among women than men (urban 67.0% vs 48.0%, P < .05; rural 56.3% vs 49.1%, P < .05).

Table 3 showed the results of the logistic regression analyses evaluating the factors associated with PA. Age, female, tobacco use, alcohol use, BMI, occupational status, salt intake, and an educational level were positively associated with the prevalence of appropriate MPA or VPA in the young and middle-aged populations.

The identified associated factors for pre-HTN were alcohol use (odds ratio [OR] 2.0, 95% CI 1.74–2.3, P < .001), tobacco use (OR 1.79, 95% CI 1.60–2.0, P < .001), obesity (OR 2.21, 95% CI 1.84–2.67, P < .001), central obesity (OR 2.32, 95% CI 2.01–2.56, P < .001); for HTN were alcohol use (OR 3.32, 95% CI 2.59–4.27, P < .001), tobacco use (OR 2.62, 95% CI 2.09–3.28, P < .001), obesity (OR 9.51, 95% CI 7.05–12.81, P < .001), central obesity (OR 4.31, 95% CI 3.49–5.31, P < .001), shown in Table 4.

Distinct duration and intensity of PA associated with pre-HTN: MPA (0 min/wk, OR 1.31, 95% CI 1.20–1.42, P < .001; 0 < duration < 420 min/wk, OR 1.14, 95% CI 1.06–1.23, P < .001; 700 ≤ duration < 1080 min/wk, OR 1.06, 95% CI 1.00–1.22, P = .042; duration ≥ 1080 min/wk, OR 1.14, 95% CI 1.04–1.26, OR = .008), and VPA (duration ≥ 1000 min/wk, OR 1.22, 95% CI 1.01–1.28, P < .001; with HTN: MPA (0 min/wk OR 2.08, 95% CI 1.46–2.97, P < .001; 0 < duration < 420 min/wk OR 1.22, 95% CI 1.07–1.27, P = .017; 700 ≤ duration < 1080 min/wk OR 1.18, 95% CI 1.13–2.48, P < .009; duration ≥ 1080 min/wk OR 2.19, 95% CI 1.57–3.35, P < .001); VPA (450 ≤ duration < 1000 min/wk OR 1.76, 95% CI 1.06–2.94, P = .028; duration ≥ 1000 min/wk OR 2.29, 95% CI 1.32–3.79, P < .002), Table 5.

Excessive and lack of PA were both found to be positively correlated with HTN and pre-HTN overall participants. Subjects who performed MPA for 420 ≤ duration < 700 min/wk had a lower prevalence of HTN than those who performed MPA for other durations and the lower prevalence of HTN among participants who performed VPA 0 ≤ duration < 180 min/wk and 180 ≤ duration < 450 min/wk. However, no significant differences were found between these 2 VPA durations (Figs 1 and 2).

4. Discussion

With increased public concern and awareness regarding health, PA as an easy and efficient intervention by individuals managing their physical fitness, especially in young and middle-aged populations. In this study, interestingly, we found that the relationship between the prevalence of HTN and PA duration was not linear but rather U-shaped, decreasing initially and then increasing with PA duration (Figs 1 and 2). Notably, individuals who regularly engage in PA for longer durations seem to be more susceptible to an elevated BP. Considering the general conventional concept of PA, we speculate that individuals were susceptible to an elevated BP. Considering the general conventional concept of PA, we speculate that individuals were susceptible to an elevated BP. Considering the general conventional concept of PA, we speculate that individuals were susceptible to an elevated BP. Considering the general conventional concept of PA, we speculate that individuals were susceptible to an elevated BP.
stiffening, subclinical myocardial damage, and coronary artery calcification.\textsuperscript{16,18} Any further increase in the frequency of strenuous exercise beyond 2 to 3 times per week was associated with an increased vascular risk in middle-aged women.\textsuperscript{25,26} Excessive endurance activities may increase the risk of cardiac abnormalities and left ventricular diastolic function, which may increase the risk for long-term morbidity or mortality.\textsuperscript{27,28} Furthermore, although exercise-based cardiac rehabilitation does reduce the risk of cardiovascular mortality, it does not reduce the risk of total mortality.\textsuperscript{29}

Compared with data from the 2002 National Epidemiological Survey (23.0% of participants with appropriate VPA and 44.7% with appropriate MPA in China).\textsuperscript{30} The prevalence of appropriate PA was higher among urban subjects than among rural. The present study reported updated information on the prevalence of PA at different intensities in young and middle-aged populations of southwest China. The results of this study indicated that approximately half of subjects were engaged in MPA more than 300 min/wk, and 1 in 5 individuals in this population engaged in VPA more than 150 min/wk. Several

### Table 2
Prevalence of prehypertension, hypertension, and physical activity \textsuperscript{(1)} by occupation, district (%).

| Occupation       | Urban area (n = 4069) | Rural (n = 4137) |
|------------------|-----------------------|------------------|
|                  | Male  | Female | Total | Male  | Female | Total |
| Incumbent        |       |        |       |       |        |       |
| HTN              | 8.1   | 4.3\textsuperscript{*} | 6.3   | 6.4   | 5.0\textsuperscript{*} | 5.7   |
| Pre-HTN          | 51.8  | 30.2\textsuperscript{*} | 41.4  | 59.5  | 45.5\textsuperscript{*} | 52.4\textsuperscript{*} |
| VPA              | 26.2  | 14.8\textsuperscript{*} | 20.7  | 27.6  | 10.2\textsuperscript{*} | 18.8  |
| MPA              | 42.1  | 63.0\textsuperscript{*} | 52.1  | 46.2  | 51.1\textsuperscript{*} | 48.7\textsuperscript{*} |
| Demission        |       |        |       |       |        |       |
| HTN              | 5.0   | 3.5    | 4.1   | 4.7   | 5.1    | 4.9   |
| Pre-HTN          | 41.9  | 27.5\textsuperscript{*} | 32.9  | 70.5  | 49.1\textsuperscript{*} | 62.6\textsuperscript{*} |
| VPA              | 24.8  | 16.9\textsuperscript{*} | 19.9  | 20.7  | 5.4\textsuperscript{*} | 13.3  |
| MPA              | 41.4  | 59.1\textsuperscript{*} | 52.5  | 32.4  | 55.7\textsuperscript{*} | 43.7\textsuperscript{*} |
| Student          |       |        |       |       |        |       |
| HTN              | 2.7   | 0.9    | 1.9   | 1.0   | 0.3    | 0.7   |
| Pre-HTN          | 48.0  | 27.3\textsuperscript{*} | 38.2  | 34.6  | 29.2    | 31.9\textsuperscript{*} |
| VPA              | 27.8  | 9.2\textsuperscript{*} | 19.0  | 14.5  | 6.9\textsuperscript{*} | 10.7\textsuperscript{*} |
| MPA              | 29.2  | 31.9\textsuperscript{*} | 30.4  | 26.6  | 16.9\textsuperscript{*} | 23.1\textsuperscript{*} |
| Total HTN        | 6.8   | 3.6    | 5.2   | 5.3   | 4.4    | 4.8\textsuperscript{*} |
| Pre-HTN          | 50.0  | 29.2\textsuperscript{*} | 39.7  | 59.4  | 43.9\textsuperscript{*} | 51.6\textsuperscript{*} |
| VPA              | 30.6  | 16.8\textsuperscript{*} | 20.3  | 28.2  | 11.1\textsuperscript{*} | 16.5  |
| MPA              | 48.0  | 67.0\textsuperscript{*} | 48.5  | 49.1  | 56.3\textsuperscript{*} | 44.1\textsuperscript{*} |

Physical activity \textsuperscript{(1)}: MPA more than 300 min/wk; VPA more than 150 min/wk.

MPA = moderate-intensity physical activity, VPA = vigorous-intensity physical activity.

\textsuperscript{*} P<.05 compared with male.

\textsuperscript{†} P<.05 compared with urban.

### Table 3
Results from logistic regression analyses assessing associated factors for physical activity.

|          | MPA                        | OR (95% CI) | P   | VPA                        | OR (95% CI) | P   |
|----------|----------------------------|-------------|-----|----------------------------|-------------|-----|
| Sex      | Male (reference)           | 1.000       |     | 1.000 (reference)           | .001        |     |
|          | Female                     | 1.295 (1.143, 1.466) | <.001 | 0.467 (0.396, 0.551) | <.001       |     |
|          | Age                        | 1.025 (1.017, 1.032) | <.001 | 1.046 (1.036, 1.055) | <.001       |     |
| Alcohol  | No (reference)             | 1.000       |     | 1.000 (reference)           | .012        |     |
|          | Yes                        | NA          |     | NA                         | .001        |     |
| Tobacco  | No (reference)             | 1.000       |     | 1.000 (reference)           | .001        |     |
|          | Yes                        | NA          |     | 1.322 (1.127, 1.551) | .001        |     |
| Obesity  | No (reference)             | 1.000       |     | 1.000 (reference)           | NA          | NA  |
|          | Yes                        | NA          |     | NA                         | NA          | NA  |
| Salt intake | <5 g/d (reference)       | 1.000       |     | 1.000 (reference)           | NA          | NA  |
|          | ≥5 g/d                     | 1.473 (1.319, 1.645) | <.001 | 1.219 (1.052, 1.412) | .009        |     |
| Occupation | Demission                  | 1.000       |     | 1.000 (reference)           | .001        |     |
|          | Incumbent                  | 1.179 (1.045, 1.332) | .008 | 1.266 (1.075, 1.490) | .005        |     |
|          | Students                   | 0.650 (0.535, 0.789) | <.001 | 2.257 (1.739, 2.929) | <.001       |     |

95% CI = 95% confidence interval, BF% = percent body fat, BMI = body mass index, MPA = moderate-intensity physical activity, OR = odds ratio, VPA = vigorous-intensity physical activity.
possible reasons may contribute to this finding. The increasing rate of PA in urban areas has been accompanied by similar parallel trends in lifestyles among urban residents, such as increased awareness regarding fitness and bodybuilding, especially among urban women. Rural residents usually focus less on their health status and have lower awareness of health.

Table 4
Comparison of clinical characters between prehypertension and hypertension.

|                | Pre-HTN      | OR (95% CI) | P   | HTN          | OR (95% CI) | P   |
|----------------|--------------|-------------|-----|--------------|-------------|-----|
| **Sex**        |              |             |     |              |             |     |
| Male           | 1.000 (reference) | .001       | 1.000 (reference) | .001       |
| Female         | 0.443 (0.404, 0.485) | <.001     | 0.441 (0.358, 0.542) | <.001     |
| **Age**        |              |             |     |              |             |     |
| Elder          | 1.000 (reference) | .001       | 1.000 (reference) | .001       |
| Youth          | 0.147 (0.124, 0.168) | <.001     | 0.253 (0.227, 0.280) | <.001     |
| **Alcohol use**|              |             |     |              |             |     |
| No             | 1.000 (reference) | .001       | 1.000 (reference) | .001       |
| Yes            | 2.000 (1.741, 2.290) | <.001     | 3.323 (2.507, 4.267) | <.001     |
| **Tobacco use**|              |             |     |              |             |     |
| No             | 1.000 (reference) | .001       | 1.000 (reference) | .001       |
| Yes            | 1.790 (1.599, 2.005) | <.001     | 2.619 (2.094, 3.275) | <.001     |
| **BMI**        |              |             |     |              |             |     |
| BMI <23.5      | 1.000 (reference) | .001       | 1.000 (reference) | .001       |
| 23.0 ≤ BMI < 27.5 | 1.750 (1.588, 1.929) | <.001     | 3.185 (2.523, 4.021) | <.001     |
| BMI ≥27.5      | 2.213 (1.837, 2.665) | <.001     | 9.506 (7.052, 12.814) | <.001     |
| **Central obesity** |              |             |     |              |             |     |
| No             | 1.000 (reference) | .001       | 1.000 (reference) | .001       |
| Yes            | 2.319 (2.088, 2.575) | <.001     | 4.306 (3.492, 5.308) | <.001     |
| **Salt intake**|              |             |     |              |             |     |
| ≥5 g/d        | 1.000 (reference) | .001       | 1.000 (reference) | .001       |
| <5 g/d        | NA            | NA         | 0.441 (0.358, 0.542) | <.001     |

95% CI = 95% confidence interval, BF% = percent body fat, BMI = body mass index, HTN = hypertension, NA = not applicable, OR = odds ratio, Pre-HTN = prehypertension.

Table 5
Association between prehypertension, hypertension, and physical activity duration in urban and rural area.

|                | Pre-HTN      | OR (95% CI) | P   | HTN          | OR (95% CI) | P   | Overall population | OR (95% CI) | P   |
|----------------|--------------|-------------|-----|--------------|-------------|-----|                   |-------------|-----|
| **MPA, min/wk**|              |             |     |              |             |     |                   |             |     |
| 0              | 1.651 (1.324, 2.058) | <.001     | 1.553 (1.242, 1.942) | <.001     |
| 0 < D < 420    | 1.379 (1.144, 1.663) | .001       | NA         | NA         | 1.143 (1.060, 1.234) | <.001     |
| 420 ≤ D < 700  | 1.000 (reference) | .001       | NA         | NA         | 1.000 (reference) | .001     |
| 700 ≤ D < 1080 | NA            | NA         | 1.358 (1.062, 1.736) | .015       |
| ≥1080          | NA            | NA         | 1.140 (1.036, 1.255) | .008       |
| **VPA, min/wk**|              |             |     |              |             |     |                   |             |     |
| 0              | NA            | NA         | 0.683 (0.516, 0.904) | .007       |
| 180 ≤ D < 450  | 1.000 (reference) | .001       | NA         | NA         | 1.000 (reference) | .001     |
| 450 ≤ D < 1000 | NA            | NA         | NA         | NA         | 1.000 (reference) | .001     |
| ≥1000          | 1.688 (1.134, 2.513) | .010       | NA         | NA         | 1.222 (1.086, 1.376) | .001     |
| **HTN**        |              |             |     |              |             |     |                   |             |     |
| MPA, min/wk    |              |             |     |              |             |     |                   |             |     |
| 0              | 2.081 (1.458, 2.969) | <.001     | 1.866 (0.995, 3.501) | .049       |
| 0 < D < 420    | NA            | NA         | 1.776 (1.008, 3.130) | .044       |
| 420 ≤ D < 700  | 1.000 (reference) | .001       | NA         | 1.000 (reference) | .001     |
| 700 ≤ D < 1080 | NA            | NA         | 2.499 (1.288, 4.851) | .005       |
| ≥1080          | 1.746 (0.996, 3.060) | .049       | 3.149 (1.694, 5.854) | <.001     |
| **VPA, min/wk**|              |             |     |              |             |     |                   |             |     |
| 0              | NA            | NA         | NA         | NA         | NA         | NA     |
| 180 ≤ D < 180  | 0.361 (0.144, 0.903) | .024       | NA         | NA         | NA         | NA     |
| 450 ≤ D < 1000 | NA            | NA         | NA         | NA         | 1.763 (1.056, 2.943) | .028     |
| ≥1000          | 3.453 (1.474, 8.092) | .003       | NA         | NA         | 2.248 (1.334, 3.786) | .002     |

95% CI = 95% confidence interval, D = duration of physical activity, HTN = hypertension, MPA = moderate intensity-physical activity, NA = not applicable, OR = odds ratio, Pre-HTN = prehypertension, VPA = vigorous-intensity physical activity.
Furthermore, subjects have an increasing risk of pre-HTN and durations of PA with a higher prevalence of HTN in their cohorts. Urban residents were better able to achieve this guideline compared with rural residents, as indicated by their reported longer awareness of the benefits of PA for their health and pursued them.[32] Immediate and future health benefits of PA have also been clearly described in young and middle-aged populations, who are recommended to engage in at least 60 minutes of VPA or MPA per day.[1] As demonstrated above, urban residents were better able to achieve this guideline than rural residents, as indicated by their reported longer durations of PA with a higher prevalence of HTN in their cohorts. Furthermore, subjects have an increasing risk of pre-HTN and HTN in urban and overall population with longer-duration of MPA and VPA, but not in rural subjects. We considered that other associated factors of pre-HTN and HTN may contribute this result after using multi-factor analysis in this study. Additionally, no benefits on pre-HTN or HTN with shorter-duration of PA (vigorous: 0–180 min/wk; moderate: 0–420 min/wk) overall population compare to recommended PA durations (vigorous: 180–450 min/wk; moderate: 420–700 min/wk). However, the reduction risks of pre-HTN and HTN were only shown in rural subjects with shorter-duration of VPA.

The prevalence of pre-HTN was higher in men than in women (54.7% vs 36.6%, P < .001) and was also higher than in other Asian countries, including Korea (41.9% vs 21.9%) and Japan (34.8% vs 31.8%).[33,34] In recent years, the age distribution of incident CVD has become younger, and pre-HTN has been associated with an increased risk of major cardiovascular events independent of other CVD risk factors.[35] Pre-HTN has been reported to significantly increase the risk of CVD and stroke mortality, and CVD mortality was significantly increased in high-range pre-HTN individuals.[36] Continuous PA was more strongly associated with reduced BP, and ongoing PA appears to be more effective than a single continuous session in the management of pre-HTN.[37] Reducing the prevalence of pre-HTN may potentially decrease the rate of CVD. Hypertensive individuals accounted for 5% of the participants, with a higher prevalence of HTN among rural residents than among urban residents, although this value is lower than that reported in a previous study.[38] The insignificant effect of salt intake on pre-HTN or HTN may be because the effect of salt consumption on young and middle-aged people has not yet been determined. Recent data show that the percentages of the population requiring treatment and control of HTN in the United States were 50.0% and 40.2%, respectively.[39] In contrast, the rates of HTN treatment and control in China were only 22.9% and 5.7%,[38] respectively. However, the definition of HTN has recently been updated in the United States.[40] Given that the previous BP cut-off value (140/90 mm Hg) still cannot be achieved, this goal may not be suitable for developing countries such as China, which may require updated, stricter guidelines. More efforts to achieve the basic requirements of BP control are warranted.

Educational level was identified as a factor associated with PA, which is consistent with data from other studies.[41] A B-level education was found to be negatively associated with PA. Compared with less-educated people, participants with higher education levels have more information and health literacy regarding the importance of healthy behaviors for healthier lifestyles.[1,42] However, the young and middle-aged populations had generally received higher levels of education[43] but still lacked appropriate health-related education.

4.1. Limitations

Some limitations should be noted. First, although the self-administered IPAQ is valid and reliable, a self-report questionnaire of PA by participants was used in this study rather than directly measuring or investigating the details of exercise type, frequency. Second, more clinical characters such as metabolic syndrome, lipids, lipids ratio, diabetes, liver steatosis, non-HDL cholesterol, COPD, gout, atrial fibrillation, high-sensitivity C-reactive protein, chronic kidney disease, fasting glucose, medications, and family history of stroke, CAD, PAD should
be included. Third, because the present study was cross-sectional in design, the findings cannot establish conclusive cause-and-effect relationships between BP and PA. Still, as the difference between rural and urban populations has grown smaller in China, a selection bias cannot be ruled out. Lastly, the results were based on the Chinese young and middle-aged populations and should be interpreted cautiously if extended to western countries.

4.2. Future directions

To be able to develop more specific guidelines, future studies should focus on identifying clinical, specific population and intervention moderators explaining “for whom” or “how much” interventions work. Further, more insight into the no-drug intervention on cardiovascular health outcomes in healthy individuals or NCDs individuals is needed to improve the efficacy and efficiency. Finally, existing programs should embrace the capabilities and preferences of participants to facilitate optimal uptake of interventions. In conclusion, current PA guidelines are generic, and more research is needed to develop more personalized PA guidelines.

5. Conclusion

Excessive PA duration may be considered as a risk factor for HTN in young and middle-aged populations. The result of this study showed that engaging in an improper PA duration is common in the young and middle-aged populations in southwest China. An appropriate recommendation of PA duration for young and middle-aged populations may reduce the risk of HTN.

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