



# The effect of an overall healthy lifestyle on early-onset stroke: a cross-sectional study

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**Background:** The impact of an overall healthy lifestyle on early-onset stroke is still unclear. Our study thus aimed to investigate the association of overall healthy lifestyle on early-onset stroke in Chinese hospitalized stroke patients.

**Methods:** This retrospective study included 821 hospitalized stroke patients from the First People's Hospital of Changzhou. An overall healthy lifestyle was defined as the presence of more than 2 of the following items: healthy diet, no smoking, normal body mass index (BMI <24 kg/m<sup>3</sup>), engaging in moderate to high physical activity (≥3 times/week, and ≥30 minutes each time). Early-onset stroke was defined as a stroke first occurring at 50 years old or younger.

**Results:** Among all participants, there were 98 early-onset stroke patients and 723 late-onset stroke patients. Early-onset patients had a lower prevalence of overall healthy lifestyles than that of late-onset patients (P<0.001). Multivariate logistic regression revealed that an overall healthy lifestyle significantly reduced the risk of early-onset stroke. In reference to those without an overall healthy lifestyle, the multivariate-adjusted odds ratios (ORs) for early-onset stroke among participants with an overall healthy lifestyle was 0.27 [95% confidence interval (CI): 0.07–0.98].

**Conclusions:** In Chinese stroke patients, a healthy lifestyle was significantly associated with early-onset stroke. Individuals who were adhering to an overall healthy lifestyle had a lower risk of early-onset stroke compared to those who were not.

**Keywords:** Early-onset stroke; healthy lifestyle; late-onset stroke; overall healthy lifestyle

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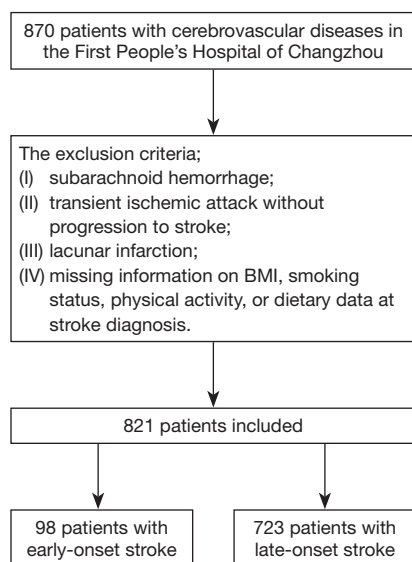
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## Introduction

Stroke is the second leading cause of death and the third main cause of disability in the world, accounting for 6.5 million deaths and 113 million disability-adjusted life years (DALY) (1). Although stroke is more common among older adults, the incidence rate of stroke occurring in young

and middle-aged adults has gradually increased by over 40% in the past few decades (2-5). The high healthcare costs and loss of labor productivity caused by stroke and the consequent and substantial socioeconomic burden has led to early-onset stroke being considered a significant public health issue (6). Therefore, it is of great importance to identify cost-effective strategies for the prevention and early



**Figure 1** Flow diagram of the participant selection. BMI, body mass index.

screening of early-onset strokes.

Previous studies found that more than 90% of the stroke burden was attributable to modifiable risk factors, such as cigarette smoking, alcohol consumption, poor diet, physical inactivity, and high body mass index (BMI) (6,7). Smoking, drinking, increased consumption of red meat, and high BMI were associated with an increased risk of stroke (7-9), while regular physical activity and increased consumption of fruit and vegetables significantly reduced the risk of stroke (7,8,10). Moreover, adhering to an overall healthy lifestyle of not smoking, engaging in moderate to high physical activity, eating a healthy diet, and having a healthy BMI, has been associated with a substantially lower risk of stroke (11,12).

However, few studies have investigated the association between a healthy lifestyle and early-onset stroke. Choi-Kwon *et al.* reported that early-onset stroke patients were less compliant in the cessation of cigarette smoking and regular exercise than late-onset stroke patients (13). A population-based cohort study in Sweden also found the incidence rate of stroke patients who were men under the age of 45 consumed  $\geq 20$  cigarettes per day, which led to them being more than 6 times more likely than nonsmoking men to have a stroke. Therefore, a dose-response association exists between smoking and risk of stroke before 45 years of age (14). Another case-control study conducted in young stroke patients revealed that an approximate 78%

risk of stroke was attributable to four potentially modifiable risk factors (hypertension, low physical activity, smoking, and alcohol consumption) (15). Likewise, low green vegetable consumption was also shown to be associated with stroke occurring before the age of 50 years old (16). Nevertheless, the effect of an overall healthy lifestyle on early-onset stroke has still not been satisfactorily clarified.

Thus, in the present study, we aimed to investigate the impact of an overall healthy lifestyle on early-onset stroke among Chinese hospitalized stroke patients.

We present the following article in accordance with the STROBE reporting checklist (available at <http://dx.doi.org/10.21037/apm-19-656>).

## Methods

### Study population

This cross-sectional study was conducted over a period of 12 months (January 2017–January 2018). The study included 870 patients who were admitted to First People's Hospital of Changzhou and were diagnosed with cerebrovascular diseases. Inclusion criteria were as follows: (I) patients who agreed to participate in the study and signed the informed consent form, (II) patients underwent computed tomography (CT) or magnetic resonance imaging (MRI) scans to confirm the presence of cerebrovascular disease. The exclusion criteria included: (I) subarachnoid hemorrhage; (II) transient ischemic attack without progression to stroke; (III) lacunar infarction; (IV) missing information on BMI, smoking status, physical activity, or dietary data at stroke diagnosis. Eventually, 821 stroke patients were included (*Figure 1*).

This study was conducted according to the Declaration of Helsinki principles (as revised in 2013) and approved by the Institutional Review Board in the First People's Hospital of Changzhou (No. 2020025). Informed consent was obtained from all individual participants included in the study.

### Data collection

Each participant completed a standard questionnaire conducted by trained interviewers for collecting sociodemographic information, medical history, and lifestyle (including smoking and drinking status, diet habit, and physical activity). Smoking status was categorized as never (including duration of passive smoking), formerly

(including duration of quitting smoking and numbers of cigarettes when smoking), and currently (including duration and numbers of cigarettes). Drinking status was categorized as never, formerly (duration of quitting drinking), currently (including duration and alcohol consumption). Diet habit was categorized as omnivorous (balanced consumption of vegetables and meat), vegetable activists, and meat activists. The duration of habit and frequency of eating vegetables and fruits per week ( $\geq 5$  or 3–4 or  $\leq 2$  days/week) were also collected. Physical activity was categorized as physically active and physically inactive. Physically active was defined as participants who participated in moderately intense physical activity  $\geq 3$  times/week and  $\geq 30$  minutes each time.

Anthropometric measurements were performed by trained personnel who collected information on blood pressure, height, and weight. After a 5-minute rest, blood pressure was measured twice with a 1-minute interval on the non-dominant arm (OMRON Model HEM-752 FUZZY, Omron Company, Dalian, China). The average of two measurements was used for analysis. The body weight and height of participants were measured while they were in barefoot and wearing light clothing. BMI was calculated as weight in kilograms divided by height in meters squared ( $\text{kg}/\text{m}^2$ ).

### **Biochemical measurements**

Measurements were taken after at minimum of 10 hours of overnight fasting, and then venous blood samples were collected. Fasting plasma glucose (FPG) was measured using the glucose oxidase method by an autoanalyzer (AU-5800 Chemistry System, Beckman, USA). Levels of triglyceride (TG), low-density lipoprotein cholesterol (LDL-c), high-density lipoprotein cholesterol (HDL-c), and total cholesterol (TC) were measured by an autoanalyzer (AU-5800 Chemistry System, Beckman, USA).

### **Definitions**

#### **Healthy lifestyle factors**

(I) No smoking was defined as participants who had never smoked (11,17). (II) Moderate to high physical activity was defined as doing moderately intense physical activity (the intensity of physical activity equal to brisk walking)  $\geq 3$  times/week, and  $\geq 30$  minutes each time (18,19). (III) A healthy diet was defined as a balanced consumption of vegetables and meat, and consumption of vegetables at least

5 days per week, and consumption of fruit at least 5 days per week (20,21). (IV) Normal BMI was defined as BMI  $< 24 \text{ kg}/\text{m}^2$  (17,20).

#### **Overall healthy lifestyle**

In the present study, an overall healthy lifestyle included the following healthy lifestyle factors: no smoking, moderate to high physical activity, healthy diet, and normal BMI (11,18,22). Participants who met the criteria for 1 of the healthy lifestyle factors would receive 1 point; otherwise, they received 0 points. A sum of points  $> 2$  was defined as an overall healthy lifestyle.

#### **Early-onset stroke**

The updated definition of stroke is an acute episode of focal dysfunction of the brain, retina, or spinal cord lasting longer than 24 h, or of any duration if imaging (CT or MRI) or autopsy showing focal infarction or hemorrhage relevant to the symptoms (23). Several editions of the *International Classification of Diseases (ICD)* were used to identify hemorrhagic stroke (*ICD 8* and *ICD 9*, codes 430–431; and *ICD 10*, codes I60–I62), ischemic stroke (*ICD 8* and *ICD 9*, codes 432–438; and *ICD 10*, codes I63–I66), and any stroke event (*ICD 8* and *ICD 9*, codes 430–438; and *ICD 10*, code I60–I66) events (22,24).

Early-onset stroke was defined as a stroke first occurring at 50 years old or younger. Meanwhile, late-onset stroke was defined as a stroke first occurring at 50 years old or older (13,25).

#### **Statistical analyses**

In the present study, continuous variables are presented as the mean  $\pm$  standard deviation for normally distributed variables and median (interquartile) for skewed variables. Categorical variables are presented as numbers (proportions). The comparisons of characteristics between early-onset stroke patients and the other stroke patients used chi-square tests for categorical variables and Student's *t*-tests for continuous variables. Chi-square tests were used to compare the prevalence of overall healthy lifestyle and each of its component between early-onset stroke patients and late-onset stroke patients. Multivariate logistic regression was used to analyze the associations of early-onset stroke with no smoking, moderate to high physical activity, healthy diet, normal BMI, and overall healthy lifestyle. Model 1 was adjusted for age and sex; model 2 was further adjusted for drinking status, self-reported history of

**Table 1** Characteristics of study population

Variables	Early-onset stroke patients	Late-onset stroke patients	P
N (%)	98 (11.9)	723 (88.1)	
Age (years)	47 [44–49]	69 [62–78]	<0.001
Male, n (%)	87 (81.3)	495 (65.5)	<0.001
Current drinker, n (%)	67 (63.6)	520 (68.8)	0.015
BMI (kg/m <sup>2</sup> )	24.5 (22.4–26.6)	23.4 (21.6–25.7)	<0.001
FPG (mmol/L)	5.6 (4.8–7.1)	5.7 (4.9–7.1)	<0.001
SBP (mmHg)	149.3±22.7	150.8±19.5	<0.001
DBP (mmHg)	91.3±15.0	83.8±12.3	<0.001
TC (mmol/L)	4.7±1.1	4.5±1.0	<0.001
HDL-c (mmol/L)	1.1±0.4	2.5±0.8	<0.001
LDL-c (mmol/L)	1.1±0.4	2.4±0.8	<0.001
TG (mmol/L)	1.8 (1.3–2.4)	1.5 (1.1–2.1)	<0.001
Self-reported hypertension, n (%)	65 (66.3)	494 (68.3)	0.084
Self-reported hyperlipidemia, n (%)	7 (7.1)	51 (7.1)	0.165
Self-reported diabetes, n (%)	17 (17.4)	174 (24.1)	0.035
Self-reported heart disease, n (%)	2 (2.0)	91 (12.6)	<0.001
Antihypertensive agents, n (%)	40 (42.9)	447 (61.8)	<0.001
Lipid lowering agents, n (%)	2 (2.0)	15 (2.1)	0.291
Antidiabetic agents, n (%)	13 (13.4)	149 (20.6)	0.025

Data were presented as mean ± SD or median (interquartile range) for continuous variables and number (%) for categorical variables. P<0.05 was considered statistically significant. FPG, fasting plasma glucose; DBP, diastolic blood pressure; SBP, systolic blood pressure, TC, total cholesterol; HDL-c, high-density lipoprotein cholesterol; LDL-c, low-density lipoprotein cholesterol; TG, total triglyceride.

heart disease, systolic blood pressure (SBP), and diastolic blood pressure (DBP), FPG, TG, and TC based on model 1; model 3 was further adjusted for antihypertensive agents, lipid-lowering agents, and antidiabetic agents based on model 2.

All analyses were conducted using the SAS software (SAS Institute, Cary, NC, USA). A two-sided P value <0.05 was considered statistically significant.

## Results

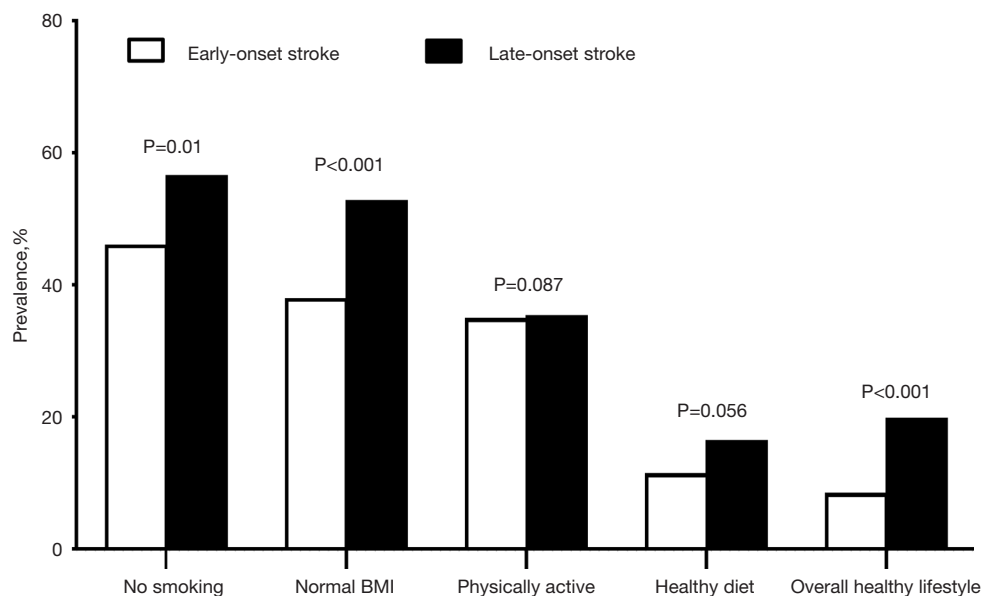
### *Characteristics of the study population*

Table 1 shows the baseline characteristics of the study population. Among all stroke patients, 98 (11.9%) were early-onset stroke patients. Compared to late-onset stroke patients, those with early-onset stroke were younger;

had more proportion of males; had higher levels of BMI, DBP, TG, and TC; but lower levels of FPG and SBP; and a lower proportion of self-reported diabetes and use of antihypertensive or antidiabetic agents (all P<0.05).

### *Prevalence of healthy lifestyle factors*

Figure 2 shows the prevalence of the overall healthy lifestyle and each of its components in the study population according to stroke-onset status. Compared to the late-onset stroke patients, the prevalence of no smoking (P=0.01), and healthy BMI (P<0.001) for early-onset stroke patients was significantly lower, but no significant difference was detected in moderate to high physical activity and healthy diet. Furthermore, the proportion of those who adhered to an overall healthy lifestyle in late-onset stroke patients was higher than that of early-onset stroke patients (P<0.001).



**Figure 2** Prevalence of overall healthy lifestyle and each of its separate components in the study population according to stroke-onset status. Data are presented as percentages for categorical variables. A P value <0.05 was considered statistically significant. BMI, body mass index.

### Healthy lifestyle factors and the risk of early-onset stroke

Multivariate logistic regression found that an overall healthy lifestyle was associated with a decreased risk of early-onset stroke (Table 2). With reference to those without an overall healthy lifestyle, the age and sex-adjusted odds ratio (OR) of early-onset stroke was 0.31 (0.09–1.05) in participants with an overall healthy lifestyle. When further adjusted for drinking status, self-reported heart diseases, SBP, DBP, FPG, TC, and TG, the risk of early-onset stroke significantly decreased 74% [OR: 0.26, 95% confidence interval (CI): 0.07–0.95] in participants with an overall healthy lifestyle. When further adjusted for the use of antihypertensive agents, lipid-lowering agents, and glucose-lowering agents, the association of an overall healthy lifestyle with early-onset stroke remained statistically significant (OR: 0.27, 95% CI: 0.07–0.98).

### Discussion

In this retrospective population-based study, we found that an overall healthy lifestyle was associated with a reduced risk of early-onset stroke. Adhering to more healthy lifestyle factors was associated with a lower risk of early-onset stroke. Our results suggest that having an overall healthy lifestyle is critical in preventing an early-onset stroke.

Stroke are a complex disease caused by both genetic

and environmental factors. As genetics, age, sex, and ethnicity are non-modifiable factors, metabolic status, and lifestyle choices may be more helpful to understanding the incurrence of stroke (26). Recently, some studies have focused on the effects of lifestyle factors on early-onset stroke. A higher risk (HR: 1.88) of stroke among the current smokers versus never smokers has been observed in a population-based case-control study focusing on the risks of ischemic stroke in men aged 15 to 49 years (27). A BMI  $\geq 25$  kg/m<sup>2</sup> significantly increased general cardiovascular risks and specific risks of stroke including young stroke cases (28). The INTERSTROKE study, a large international case-control study, recruited 13,447 stroke cases and found that regular physical activity and a healthy diet reduced the risk of stroke among adults aged 55 years old or younger (OR: 0.60, 95% CI: 0.45–0.80 and OR: 0.68, 95% CI: 0.55–0.86, respectively). Current smoking and heavy alcohol intake also increased the risk of stroke (OR: 1.66, 95% CI: 1.36–2.02 and OR: 2.20, 95% CI: 1.49–3.23, respectively) (29). In our study, after adjustment for confounding factors, no statistically significant association was detected between any single lifestyle factor (no smoking, moderate to high physical activity, healthy diet, and normal BMI) and risk of early-onset stroke, which is inconsistent with previous studies. This may be attributed to the small sample size and participants recruited from a single center. However, the

**Table 2** The association of overall healthy lifestyle factors and the risk of early-onset stroke

Variables	OR (95% CI)		
	Model 1	Model 2	Model 3
No smoking			
No	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)
Yes	0.96 (0.38–2.32)	0.87 (0.35–3.28)	0.95 (0.37–2.46)
Normal BMI (kg/m <sup>2</sup> )			
No	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)
Yes	0.75 (0.35–1.58)	0.67 (0.30–1.46)	0.67 (0.30–1.48)
Moderate to high physical activity			
No	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)
Yes	0.74 (0.34–1.60)	0.76 (0.34–1.71)	0.76 (0.34–1.73)
Healthy diet			
No	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)
Yes	1.40 (0.41–4.78)	1.40 (0.39–5.06)	1.46 (0.40–5.27)
Overall healthy lifestyle			
No	1.00 (Ref.)	1.00 (Ref.)	1.00 (Ref.)
Yes	0.31 (0.09–1.05)	0.26 (0.07–0.95)	0.27 (0.07–0.98)

Model 1: adjusted for age (years), sex (men/women). Model 2: further adjusted for drink (yes/no), self-reported heart disease (yes/no), SBP, DBP, FPG, TG, TC based on model 1. Model 3: further adjusted for use of antihypertensive agents, lipid lowering agents and antidiabetic agents based on model 2. BMI, body mass index; OR, odds ratio; 95% CI, 95% confidence interval; Ref., reference; SBP, systolic blood pressure, DBP, diastolic blood pressure; FPG, fasting plasma glucose; TG, total triglyceride; TC, total cholesterol.

overall healthy lifestyle was significantly associated with the decreased risk of early-onset stroke, which was in line with the previous studies.

The major strength of our study was the design of investigating the overall effects of healthy lifestyle factors on the risk of early-onset stroke. To our knowledge, this is the first population-based study that showed an association between an overall healthy lifestyle and a reduced risk of early-onset stroke. Additionally, the diagnosis of stroke was dependent on the imaging, which was more accurate than self-reported events in other studies. However, several limitations of our study should also be noted. Firstly, the sample size of our research was not large, with 98 early-onset stroke cases and 723 late-onset stroke cases (16,30). However, participants in the present study were measured by CT/MRI, and inpatients were diagnosed by physicians; these measures are more reliable than large sample sizes of self-reported medical histories.

Moreover, the proportion of early-onset stroke is similar to previous studies. Ekker reported that 1 in 10 strokes

were in young adults (25), while in our study, 11.9% [98] were early-onset stroke patients. Secondly, our study was retrospective in design, so a causal inference cannot be drawn, and thus the prospective study is warranted in the future. Thirdly, our study was conducted in Chinese hospitalized patients. Hence, caution should be taken in generalizing the results to other ethnicities. Finally, the information on lifestyle factors was self-reported, so some recall bias was unavoidable in our study. The additional validation of lifestyle factors should be undertaken in a future follow-up study.

## Conclusions

In conclusion, the present study showed that adhering to an overall healthy lifestyle was significantly associated with a reduced risk of early-onset stroke. The power of an overall healthy lifestyle was more significant than any single component of a healthy lifestyle alone. These findings further support the current recommendation that

patients at high risk for stroke should practice a healthy lifestyle to improve their health and maintain a lower risk of developing early-onset stroke. Further prospective studies were warranted to verify the association of an overall healthy lifestyle with the incident of early-onset stroke.

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### Footnote

*Reporting Checklist:* The authors have completed the STROBE reporting checklist. Available at <http://dx.doi.org/10.21037/apm-19-656>

*Data Sharing Statement:* Available at <http://dx.doi.org/10.21037/apm-19-656>

*Conflicts of Interest:* All authors have completed the ICMJE uniform disclosure form (available at <http://dx.doi.org/10.21037/apm-19-656>). The authors have no conflicts of interest to declare.

*Ethical Statement:* The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The present study was approved by the Institutional Review Board in the First People's Hospital of Changzhou (No. 2020025) and was conducted in compliance with the Declaration of Helsinki (as revised in 2013). Written informed consent forms were obtained from all subjects.

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