Preplanned Studies

Associations Between Changes in Physical Activity and Risk of All-Cause Mortality in Adults With/Without Hypertension — China, 2010–2022

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Summary

What is already known about this topic?

Previous studies indicate that an increase in physical activity can diminish the risk of mortality. However, the relationship between longitudinal changes in physical activity and health improvement among Chinese adults with or without hypertension has not been explored.

What is added by this report?

This study found that increasing or maintaining moderate to high physical activity levels reduced the risk of all-cause mortality, irrespective of the baseline physical activity level. In addition, the beneficial effects were particularly pronounced in people with hypertension.

What are the implications for public health practice?

It may be beneficial to encourage adults in China, especially those with hypertension, to actively increase physical activity and deter the issue of physical inactivity that accompanies aging.

Hypertension and physical inactivity are significant contributors to global mortality and are modifiable risk factors for many chronic diseases. Physical inactivity is prevalent in China, where the weighted prevalence of hypertension in adults was 27.5% and rising (*1*). Previous research suggests that physical inactivity may increase mortality risk, particularly among individuals with hypertension (*2*). However, research on longitudinal changes in physical activity (PA) and mortality among hypertensive individuals in China is limited. Therefore, we used baseline data from the 2010 China Chronic Disease and Risk Factor Surveillance (CCDRFS) and conducted follow-up from 2016 to 2017 to assess changes in PA and their impact on mortality among adults with and without hypertension. Our findings indicate that individuals who increased their PA levels had a lower risk of all-cause mortality than those who remained inactive, regardless of hypertension status. This survival advantage was more pronounced among individuals with hypertension. These results underscore the importance of encouraging individuals with hypertension to increase or maintain moderate to high PA levels to improve longevity and overall health.

The CCDRFS is a periodic series of nationally representative surveys conducted every three years (every five years since 2018) since 2004, focusing on chronic health status and related risk factors among Chinese adults. In this study, ten provinces (Hebei, Jilin, Heilongjiang, Zhejiang, Jiangxi, Henan, Hunan, Sichuan, Guizhou, and Shanxi) were selected from the 2010 CCDRFS, and two monitoring sites (one in an urban area and one in a rural area) were selected in each province. A follow-up survey was conducted from 2016 to 2017, and data on all-cause mortality until December 2022 were obtained from the Cause of Death Reporting System of the China CDC. Initially, 10,874 participants were enrolled at baseline. After excluding 2,985 participants lost to follow-up and 407 participants lacking key covariate information, the final analysis sample included 7,482 individuals.

Baseline and follow-up surveys included inquiries, physical measurements, and laboratory tests. PA was assessed by inquiring about the intensity and duration of various physical activities in a typical week, such as farm work, housework, transportation-related activities, exercise, and recreational activities. PA was quantified as metabolic equivalent of task minutes per week (MET-min/week). Participants were categorized into low (<600 MET-min/week), moderate (600 to 3,000 MET-min/week), and high (≥3,000 MET-min/week) physical activity level (PAL) at baseline and follow-up (*3*). Changes were classified into nine groups within the three categories of baseline PAL: low-to-low, low-to-moderate, low-to-high, moderate-to-low, moderate-to-moderate, moderate-to-high, high-to-low, high-to-moderate, and high-to-high.

For further details, refer to the 2010 CCDRFS and other relevant literature (*4*–*5*). The study was sanctioned by the Ethics Committee of the National Center for Chronic and Noncommunicable Disease Control and Prevention, Chinese Center for Disease Control and Prevention, and all participants provided informed consent.

Descriptive data are presented as mean±standard deviation (SD), frequency (percentage), or median [interquartile range (IQR)]. Baseline characteristics were compared using *t*-tests or chi-square tests. Cox proportional hazards regression models were employed to evaluate the associations between changes in PAL and all-cause mortality. Statistical analyses were conducted using SAS (version 9.4; SAS Institute Inc., Cary, NC, USA), with two-tailed tests at a significance level of 0.05.

Table 1 outlines the baseline characteristics of the participants, with an average age of 46.96 and 43.20% male. Hypertension was present in 39.56% of participants. Statistically significant differences were observed in all baseline characteristics analyzed, except for current drinking and PAL. Compared with the non-hypertension group, the hypertension group was older, had a higher proportion of male and rural residents, included more people with low education and poor dietary habits, and had a higher prevalence of chronic diseases (all $P<0.05$).

During an average follow-up period of 11.88±1.89 years, 215 deaths occurred. Table 2 demonstrates the association between changes in PAL and all-cause mortality. After adjusting for sex, age, smoking and drinking status, diabetes mellitus, dyslipidemia, abdominal obesity, obese or overweight, fruit and vegetable intake, red meat intake, and residence, most groups exhibited a significantly reduced risk of all-cause mortality following changes in PAL compared to the low-to-low group. Notably, the high-to-low group experienced less risk reduction [hazard ratios (HR)=0.41, 95% confidence interval (*CI*): 0.24, 0.70] than the high-to-high group (HR=0.25, 95% *CI*: 0.16, 0.41) and the moderate-to-moderate groups (HR=0.25, 95% *CI*: 0.13, 0.47). Similar results were observed regardless of hypertension status. Additionally, hypertension acted as a significant effect modifier of the association between PA change and all-cause mortality (P for interaction <0.001). Increasing PAL brings greater health benefits, while decreasing PAL brings a greater risk of death. For example, among hypertensive individuals, the high-to-high group demonstrated a 78% lower risk of all-cause mortality (HR=0.22, 95% *CI*: 0.12, 0.41) compared to the low-to-low group, while among those without hypertension, the risk reduction was 67% (HR=0.33, 95% *CI*: 0.15, 0.71). Moreover, a larger proportion of deaths were attributed to PAL changes from high to low among hypertensive individuals compared to non-hypertensive individuals.

Table 3 presents the results of subgroup analyses among participants with hypertension. Using the low-to-low group as a reference, only sex and current smoking status were found to modify the association between change in PAL and all-cause mortality among adults with hypertension (P value for interaction <0.05).

DISCUSSION

This study identified a significant link between reduced all-cause mortality risk and changes in PAL, particularly among individuals with hypertension. Therefore, regardless of baseline PAL, increasing PA or maintaining a moderate to high PAL may be beneficial.

Our findings parallel prior research focusing on PAL changes in the general population. For instance, in the Prediction for Atherosclerotic Cardiovascular Disease Risk in China (China-PAR) study involving 100,554 participants, those maintaining moderate or high PAL reduced their death risk by 34% over a median 7.3-year follow-up (*5*). Similarly, findings from the Guangzhou Biobank Cohort Study indicated that compared to individuals sustaining moderate PAL, those transitioning from high or moderate to low PAL faced elevated all-cause mortality risk, whereas those maintaining or increasing high PAL experienced lower mortality risk (*6*). Intriguingly, the study noted that shifting to high PAL conferred benefits similar to sustaining high PAL, aligning with our study's implications for motivating those with low initial PAL to elevate their activity levels.

Our research highlighted the amplified benefits of increasing PAL among hypertensive participants compared to non-hypertensive ones (P for interaction <0.001), consistent with findings from the Korea National Health Insurance Service (KNHIS) database (*7*). Additionally, a negative correlation between total PA and reduced all-cause mortality risk was observed among hypertensive adults in China (*8*). However, this study, measuring PA at a single time point, overlooked PA changes over time. Notably, we observed a greater proportion of deaths in hypertensive patients transitioning from high to low PAL compared to non-

TABLE 1. Baseline characteristics of participants by hypertension in China, 2010.

Characteristics	Total (*N*=7,482)	Non-hypertension (*N*=4,522)	Hypertension (*N*=2,960)	*P*
All-cause death, *n* (%)	215 (2.87)	86 (1.90)	129 (4.36)	<0.001
Age, mean±SD, years	46.96±13.50	42.86±12.71	53.22±12.21	<0.001
Age group, years, *n* (%)				<0.001
18–44	3,269 (43.69)	2,555 (56.50)	714 (24.12)	
45–59	2,825 (37.76)	1,481 (32.75)	1,344 (45.41)	
60 and above	1,388 (18.55)	4,86 (10.75)	902 (30.47)	
Sex, *n* (%)				0.018
Male	3,232 (43.20)	1,904 (42.11)	1,328 (44.86)	
Female	4,250 (56.80)	2,618 (57.89)	1,632 (55.14)	
Education, *n* (%)				<0.001
Elementary school/below	3,470 (46.38)	1,863 (41.20)	1,607 (54.29)	
Junior high school	2,320 (31.01)	1,491 (32.97)	829 (28.01)	
High school or technical secondary school	1,036 (13.85)	672 (14.86)	364 (12.30)	
College degree and above	656 (8.76)	496 (10.97)	160 (5.40)	
Marital status, *n* (%)				<0.001
Unmarried	428 (5.72)	357 (7.89)	71 (2.40)	
Married or living together	6,360 (85.00)	3,836 (84.83)	2,524 (85.27)	
Divorced/separated/other	694 (9.28)	329 (7.28)	365 (12.33)	
Residence, *n* (%)				0.001
Urban	3,348 (44.75)	2,096 (46.35)	1,252 (42.30)	
Rural	4,134 (55.25)	2,426 (53.65)	1,708 (57.70)	
Current smoking, *n* (%)				<0.001
Yes	2,123 (28.37)	1,321 (29.21)	802 (27.09)	
No	5,359 (71.63)	3,021 (70.79)	2,158 (72.91)	
Current drinking, *n* (%)				0.079
Yes	2,887 (38.59)	1,781 (39.39)	1,106 (37.36)	
No	4,595 (61.41)	2,741 (60.61)	1,854 (62.64)	
Obese or overweight, *n* (%)				<0.001
Yes	3,607 (48.21)	1,717 (37.97)	1,890 (63.85)	
No	3,875 (51.79)	2,805 (62.03)	1,070 (36.15)	
Abdominal obesity, *n* (%)				<0.001
Yes	2,160 (28.87)	897 (19.84)	1,263 (42.67)	
No	5,322 (71.13)	3,625 (80.16)	1,697 (57.33)	
Dyslipidemia, *n* (%)				<0.001
Yes	366.7 (49.01)	2,126 (47.01)	1,541 (52.06)	
No	3,815 (50.99)	2,396 (52.99)	1,419 (47.94)	
Diabetes mellitus, *n* (%)				<0.001
Yes	508 (6.79)	190 (4.20)	318 (10.74)	
No	6,974 (93.21)	4,332 (95.80)	2,642 (89.26)	
Insufficient intake of fruits and vegetables, *n* (%)				<0.001
Yes	3,719 (49.71)	2,163 (47.83)	1,556 (52.57)	
No	3,763 (50.29)	2,359 (52.17)	1,404 (47.43)	

Continued

Characteristics	Total (*N*=7,482)	Non-hypertension (*N*=4,522)	Hypertension (*N*=2,960)	*P*
Excessive intake of red meat, *n* (%)				<0.001
Yes	2,270 (30.34)	1,568 (34.67)	702 (23.72)	
No	5,212 (69.66)	2,954 (65.33)	2,258 (76.28)	
SBP (mmHg), M (IQR)	131.00 (27.00)	121.67 (15.00)	152.00 (22.33)	<0.001
DBP (mmHg), M (IQR)	81.33 (15.33)	76.00 (10.33)	92.00 (13.00)	<0.001
PAL, *n* (%)				0.447
Low	1,050 (14.03)	616 (13.62)	434 (14.66)	
Moderate	2,519 (33.67)	1,528 (33.79)	991 (33.48)	
High	3,913 (52.30)	2,378 (52.59)	1,535 (51.86)	

Abbreviation: SD=standard deviation; M=median; IQR=interquartile range; SBP=systolic blood pressure; DBP=diastolic blood pressure; PAL=physical activity level.

TABLE 2. HRs (95% *CI*s) associated with the all-cause mortality risk for various changes in physical activity level among Chinese adults during 2010–2022.

Change in PAL	Deaths/*N*	Person-years	Mortality rate (per 1,000 person-years)	HR (95% *CI*) for all-cause mortality	
				Crude HR (95% *CI*)	AHR (95% *CI*)
Total					
Low-to-low	28/337	4,016.58	6.97	1.00 (reference)	1.00 (reference)
Low-to-moderate	12/338	4,095.75	2.93	0.42 (0.21, 0.82)*	0.36 (0.18, 0.71)*
Low-to-high	10/375	4,527.68	2.21	0.31 (0.15, 0.65)*	0.31 (0.15, 0.64)*
Moderate-to-low	30/617	7,235.09	4.15	0.58 (0.35, 0.97)*	0.63 (0.38, 1.06)
Moderate-to-moderate	15/796	9,642.62	1.56	0.22 (0.12, 0.41)*	0.25 (0.13, 0.47)*
Moderate-to-high	25/1,106	13,289.99	1.88	0.27 (0.16, 0.46)*	0.29 (0.17, 0.51)*
High-to-low	25/733	8,822.53	2.83	0.40 (0.24, 0.69)*	0.41 (0.24, 0.70)*
High-to-moderate	26/1,043	12,585.13	2.07	0.29 (0.17, 0.50)*	0.31 (0.18, 0.53)*
High-to-high	44/2,137	25,857.22	1.70	0.24 (0.15, 0.39)*	0.25 (0.16, 0.41)*
Non-hypertension					
Low-to-low	9/171	2,054.06	4.38	1.00 (reference)	1.00 (reference)
Low-to-moderate	2/196	2,377.66	0.84	0.19 (0.04, 0.88)*	0.20 (0.04, 0.91)*
Low-to-high	4/249	3,014.73	1.33	0.30 (0.09, 0.98)*	0.32 (0.10, 1.03)
Moderate-to-low	9/365	4,410.60	2.04	0.47 (0.18, 1.17)	0.56 (0.22, 1.41)
Moderate-to-moderate	7/487	5,896.90	1.19	0.27 (0.10, 0.73)*	0.34 (0.13, 0.93)*
Moderate-to-high	13/676	8,093.58	1.61	0.36 (0.16, 0.85)*	0.41 (0.18, 0.97)*
High-to-low	8/427	5,160.87	1.55	0.35 (0.14, 0.92)*	0.37 (0.14, 0.95)*
High-to-moderate	12/618	7,459.24	1.61	0.37 (0.15, 0.87)*	0.42 (0.17, 0.99)*
High-to-high	22/1,333	16,127.03	1.36	0.31 (0.14, 0.68)*	0.33 (0.15, 0.71)*
Hypertension					
Low-to-low	19/166	1,962.52	9.68	1.00 (reference)	1.00 (reference)
Low-to-moderate	10/142	1,718.08	5.82	0.59 (0.28, 1.27)	0.47 (0.21, 1.02)
Low-to-high	6/126	1,512.96	3.97	0.41 (0.15, 0.94)*	0.36 (0.14, 0.90)*
Moderate-to-low	21/252	2,824.48	7.43	0.73 (0.39, 1.35)	0.70 (0.37, 1.30)
Moderate-to-moderate	8/309	3,745.71	2.14	0.22 (0.09, 0.50)*	0.21 (0.09, 0.47)*
Moderate-to-high	12/430	5,196.41	2.31	0.24 (0.11, 0.49)*	0.24 (0.12, 0.50)*
High-to-low	17/306	3,661.66	4.64	0.48 (0.25, 0.92)*	0.44 (0.23, 0.85)*

Continued

Change in PAL	Deaths/*N*	Person-years	Mortality rate (per 1,000 person-years)	HR (95% *CI*) for all-cause mortality	
				Crude HR (95% *CI*)	AHR (95% *CI*)
High-to-moderate	14/425	5,125.89	2.73	0.28 (0.14, 0.56)*	0.27 (0.13, 0.53)*
High-to-high	22/804	9,730.19	2.26	0.23 (0.12, 0.43)*	0.22 (0.12, 0.41)*
P for interaction				<0.001	<0.001

Note: Adjusted for sex, age, smoking, drinking, diabetes mellitus, dyslipidemia, abdominal obesity, obese or overweight, fruit and vegetable intake, red meat intake, and residence.
Abbreviation: PA=physical activity; PAL=physical activity level; HR=hazard ratio; AHR=adjusted hazard ratio; *CI*=confidence interval.
* *P*<0.05.

TABLE 3. Subgroup analyses of the association between changes in physical activity and all-cause mortality among participants with hypertension.

Characteristics	HR (95% *CI*s)	*P* for interaction
Age group, years		0.099
<60	3.31 (0.36, 30.17)	
≥60	0.27 (0.13, 0.57)	
Sex		0.017
Male	0.68 (0.24, 1.91)	
Female	0.28 (0.11, 0.74)	
Residence		0.140
Urban	0.92 (0.28, 2.99)	
Rural	0.18 (0.08, 0.39)	
Current smoking		0.030
Yes	0.60 (0.20, 2.08)	
No	0.36 (0.17, 0.77)	
Current drinking		0.413
Yes	0.68 (0.18, 2.55)	
No	0.30 (0.14, 0.65)	
Obese or overweight		0.903
Yes	0.41 (0.18, 0.96)	
No	0.26 (0.10, 0.69)	
Abdominal obesity		0.205
Yes	0.27 (0.12, 0.62)	
No	0.68 (0.22, 2.13)	
Dyslipidemia		0.503
Yes	0.34 (0.13, 0.88)	
No	0.30 (0.13, 0.69)	
Diabetes mellitus		0.321
Yes	0.58 (0.12, 2.75)	
No	0.28 (0.15, 0.59)	

Note: Take the low-to-low group as a reference, and report the hazard ratios of high-to-high group; Adjusted for age, sex, smoking, drinking, fruit and vegetable intake, red meat intake, diabetes mellitus, dyslipidemia, abdominal obesity, and residence.
Abbreviation: *HR*=hazard ratio; *CI*=confidence interval.

hypertensive individuals or those maintaining moderate PAL, underscoring the importance of avoiding significant declines in physical activity.

The biological mechanisms underlying the synergistic effects between PAL changes and hypertension remain unclear (*6*–*7*). Existing literature suggests that PA may mitigate mortality risk by enhancing cardiovascular structure and function and regulating systemic metabolism, among other mechanisms. Another Chinese population-based cohort study supported a joint association between PAL and smoking with mortality in hypertensive individuals, reporting that increasing PALs might counteract some of the extra risks from smoking (*9*). This study also indicated that, among different PALs, non-smokers had lower mortality risks than smokers (*9*). This helps explain our finding that non-smokers who increased their PAL had a lower mortality risk. These findings suggest that increasing physical activity while quitting smoking may provide additional benefits. Moreover, subgroup analysis also shows sex differences in the relationship between changes in PAL and the risk of mortality. However, several studies did not find such differences in effects (*10*). This discrepancy may be due to different measurement methods and gender ratios. Therefore, further research is needed to confirm this relationship.

This study has several limitations. First, reliance on self-reported PA introduces inevitable recall bias and potential social desirability bias, which may result in inaccurate reporting. Second, the relatively small number of deaths may have constrained the statistical power to identify influential covariates, thereby limiting the interpretation of negative comparative findings. Future research should utilize objective methods, such as activity monitors, to measure physical activity and expand the sample size and explore a broader range of contexts to further validate the conclusions of this study.

In conclusion, our study underscores the link between increased PA and reduced all-cause mortality,

with stronger associations observed among hypertensive patients maintaining moderate or high PAL. Hence, advocating for sustained PA and preventing age-related declines in physical activity is crucial, along with efforts to promote the attainment of moderate PAL levels.

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