The Impact of Different Levels of Physical Activity on Health among Middle-Aged and Elderly Chinese Adults

*Jing GUAN [1], Guojun WANG [2], Chunli GENG [3]

1. School of Economics, Beijing Technology and Business University, Beijing, China
2. School of Insurance and Economics, University of International Business and Economics, Beijing, China
3. Sales Management Department, PICC Property and Casualty Company Limited, Beijing, China

*Corresponding Author: Email: guanjing@btbu.edu.cn

Abstract

Background: There is a lack of specific study of the impact of physical activities on middle-aged and elderly adults in developing countries. We aimed to investigate the causal impact of different levels of physical activity on self-rated health status for Chinese adults with an average age of 61 yr from years 2011 to 2015.

Methods: China Health and Retirement Longitudinal Study (CHARLS) conducted by the Peking University of China was utilized which was a longitudinal database and thus allowed to control for the effect of unobserved individual heterogeneities. In this study, this control was carried out using fixed effect and propensity score matching methods. In addition, this study further took into consideration of the discrete feature of our response variable, self-rated health status, by applying an ordered logit model.

Results: Participating in moderate-to-vigorous physical activity significantly increased individuals' self-rated health status ($P<.05$) whereas lower intensity physical activity did not increase individuals' self-rated health status.

Conclusion: Moderate-to-vigorous physical activity is an important instrument to improve the health status of middle-aged and elderly population in China. Government should encourage people to involve in more moderate-to-vigorous physical activity as it is an efficient way to improve individuals' health status.

Keywords: Physical activity; Self-rated health status; Propensity score matching

Introduction

Recently, the importance of physical exercise has been emphasized all around the world and many nations have prioritize their efforts in encouraging their people to get involved into physical activities (1-3). For example, the importance of promoting physical activity is acknowledged by the State Council of the People's Republic of China in the National Fitness Program (2016-2020), aiming to promote physical activity participation nationwide as a way to improve national health status (4). This has also led to increasing attraction to investigate the impact of physical activity on health status among academicians and policy makers.

Physical activity improves individuals' health though mechanisms of strengthening the immune system and prevention of diseases like depression, diabetes and cancer (1, 5-8), however, these studies were based on experimental intervention research which is generally associated with limitations, namely difficulty in randomizing the treated and control groups, lower number of observations and related ethical or moral issues (9). Therefore, analyzing observational studies is considered to be a good method to draw general

conclusions, especially in real world with complex information (10).

Physical activity improves health status for people in Canada (11), West Germany (12), UK (13) and Peru (14). The impact of physical activity depends highly on the intensity of it. For example, higher intensity physical activity is crucial to the health of young people (15, 16). However, previous observational studies had focused on either the adults in developed countries (11-13) or the children in developing countries (14). There is a lack of investigation in the impact of physical activity on health among adults in developing countries.

To address this gap in knowledge, this study examined the impact of different levels of physical activity on health status among middle-aged and elderly adults in China. It is important that China and other developing countries have a better understanding of this relationship as it could help the government to have a clear guidance of proceeding fitness programs among the middle-aged and elderly populations. This could be a potential way to improve their health status and help them to have a better quality of life.

Methods

Study design

This study used data from the China Health and Retirement Longitudinal Study (CHARLS) conducted by the Peking University of China. CHARLS was a nationally representative survey which covered 28 provinces in mainland China(There are 31 provinces in mainland China. Xizhang, Hainan and Ningxia provinces were not included into the survey sample.). It targeted individuals more than or equal to 45 years old. In the year 2011, it conducted the baseline survey, and since then a full follow up survey was conducted every other year. The survey conducted in 2015 was the most recent data available.

Participants

CHARLS provided information at the individual, family and community levels and reported demo-graphic characteristics, family information, health status and living habits information. Our analysis period comprised individuals in the baseline year 2011 and subsequent observations of the same individuals for the years 2013 and 2015. We had 5447 observations in total after dropping ones with missing values.

Ethics approval

The CHARLS data are publicly available and open to researchers all over the world. The current study is a secondary analysis of the deidentified CHARLS data. Therefore, the researchers have no access to personal identifiers or personal health information that can be linked to individuals while analyzing the data.

Variables
Health status

Our response variable was self-rated health status (SRHS). SRHS measured the individuals' general health at present, and it was an ordinal indicator taking discrete values from 1 to 5, which corresponded to an individual's health being self-evaluated as very good, good, fair, poor or very poor, respectively. It is a common measurement for health status and has been used in various related previous studies (17-19).

Physical activities

Our treatment variables were related to the participation of physical activities (PA). They were binary answers to the questions of whether an individual took vigorous physical activities or moderate physical activities, or walk for at least 10 minutes continuously every week, which were abbreviated to VPA, MPA and WALK. CHARLS defined VPA as activities which made people breathe much harder than normal and might include heavy lifting, digging, plowing, aerobics, fast bicycling, and cycling with a heavy load; MPA as activities which made individuals breathe somewhat harder than normal and might include carrying light loads, bicycling at a regular pace, or mopping the floor; WALK as walking that individuals might do solely for recreation, sport, exercise, or leisure. Similar treatment variables have

been used before to distinguish the different intensities of physical activity (20).

Control variables

Control variables in the present study were age, age square (age^2), education level, marital status, registration type (hukou), deposit, gender, urban and community activity. These variables could be deemed important determinants of health. Education level was a categorical variable which took values from 1 to 3 depending on whether an individual did not have formal education, did not have bachelor' degree or had bachelor' degree, respectively. Marital status was a binary variable which took 1 or 0 depending on whether an individual was married or not. Hukou took values 1 to 4 depending on whether an individual had an agricultural hukou, non-agricultural hukou, unified residence hukou or did not have hukou, respectively. Hukou highly depended on the place people were born and was associated with the living conditions in people's childhood. In addition, social welfares including types of social insurances were also based on hukou, which could influence individuals' health conditions (21). Deposit was a continuous variable measuring the amount of Chinese yuan (CNY) an individual had in the bank. Rich people were typically more able to get necessary medical treatments. Gender was a binary variable that took value 1 or 0 depending on whether an individual was male or female. Urban was a binary variable which took 1 or 0 depending on whether an individual lived in an urban area or a rural area. This variable was important because it was observed that the urban areas in general had better medical services and living condition (22). Community activity took value 1 or 0 depending on whether an individual participated in a community-related organization or not. It was included because the interaction with people could influence people's health (23).

Data analysis

Our purpose was to estimate the causal impact of different levels of PA on individuals' health which was measured by SRHS. The statistical software Stata, version 13.0 (Stat Corp. LP, Col-

lege Station, Texas, USA), was used to analyze the data. It should be noted that individuals' PA decisions and their SRHS could be affected by unobservable individual characteristics. Therefore, in order to control for them, we considered two methodologies: fixed effect (FE) and propensity score matching (PSM).

Fixed effect (FE) is based on the following regression model No. 1:

$$Y_{it} = \alpha_1 PA_{it} + \alpha_2 X_{it} + \gamma_i + \varepsilon_{it},$$

where Y_{it} is the SRHS for individual i in year t; PA_{it} and X_{it} correspond to our treatment variables and control variables respectively for year t and individual i. To be more clear, we estimated different equations for different definitions of PA_{it} regarding VPA_{it}, MPA_{it} and $WALK_{it}$, in order to capture the impact of different levels of PA on SRHS. γ_i is individual fixed effect that controls for unobservable time-invariant characteristics of individuals; ε_{it} is the error component and a_j, where $j = 1$ or 2 are parameters to be estimated. Our focus estimation was a_1 which represents the estimate of the causal impact of different levels of PA on individuals' SRHS.

If there were changes in SRHS due to factors other than PA which were different between treated and control groups, then the FE estimation could be biased. Rosenbaum and Rubin (24) proposed PSM method to reduce this bias in the estimation of treatment effects with observational data sets. Following their method, we applied an observational study to approximate the randomized trial in order to obtain objective causal inference. We obtained similar individuals in the treated and control groups by using the kernel matching method. This approach constructed the counterfactual individual in the control group by giving closer individuals higher weights (25). An individual belonged to the treated group if PA took value 1 while he or she belonged to the control group if PA took value 0. We restricted our sample to common support by deleting all observations with propensity scores (probabilities) larger than the smallest maximum and smaller than the

largest minimum of the treated and control groups defined by PA.

It was also necessary to adjust FE and PSM methods from linear cases to non-linear cases as our response variable was coded on a discrete and ordinal scale. Therefore, an ordered logit model was considered to estimate the marginal effects of different levels of PA on SRHS.

Results

General characteristics

The characteristics of the 5447 study participants are summarized in Table 1. Our samples were mainly middle-aged and elderly people with an average age of 61. 49% of participants were male. 28% of participants were living in urban areas.

Table 1: Statistical description of variables

Variable	Mean	Standard Deviation	Minimum	Maximum
SRHS	2.91	0.93	1	5
VPA	0.35	0.48	0	1
MPA	0.55	0.50	0	1
WPA	0.80	0.40	0	1
Age	61.21	9.20	45	105
Age²	3830.81	1174.38	2025	11025
Education	1.76	0.48	1	3
Marriage	0.82	0.38	0	1
Hukou	1.20	0.41	1	4
Deposit (CNY)	11262.09	55769.23	0	2000000
Gender	0.49	0.50	0	1
Urban	0.28	0.45	0	1
Community	0.02	0.15	0	1

Linear analysis of PA for SRHS

Table 2 shows the estimated impact of different levels of PA on individuals' SRHS for the two above discussed approaches: FE and PSM. For the sake of brevity, only the estimations of the focus parameters are reported. Under the PSM method, the average treatment effect estimation (ATE) is presented. Columns 2, 4 and 6 show the results from the FE estimation for VPA, MPA and WALK, respectively and columns 3, 5 and 7 present PSM estimations for VPA, MPA and WALK, respectively.

Both estimation methods consistently showed that MPA significantly increased individuals' SRHS. To be more specific, MPA significantly increased individual's SRHS between 0.099 to 0.158 units using PSM and FE methods, respectively. We also found some evidence that VPA could increase individuals' SRHS by 0.078 unites, however, the estimation was only significant under PSM method and not for FE method. We found that WALK did not provide a significant improvement on the SRHS. This could due to the reason that walking requires very few physical efforts and thus do not have a significant effect on individuals' SRHS. It was important to test if our control variables achieve good balance after matching under PSM method (26). As it was discussed in the Methods section, the changes in SRHS should not due to factors other than PA, therefore, the control variables should not be significantly different between the treated and control groups after matching. One way to test good balance is to check the standardized mean differences of covariates between the two groups after balancing.

Table 2: Impact of different levels of PA on individuals' SRHS

| | VPA | | MPA | | WALK | |
	FE	PSM	FE	PSM	FE	PSM
PA	-0.066	-0.078***	-0.158***	-0.099***	-0.043	-0.048
	(-0.99)	(-2.80)	(-2.82)	(-3.77)	(-0.55)	(-1.46)
R-square	0.014	0.002	0.025	0.003	0.013	0.001
#Obs.	5447	5446	5447	5435	5447	5410

Notes: T statistics in parentheses. * $P<0.1$ ** $P<0.05$ *** $P<0.01$. The number of observations was less than 5447 under PSM approach. This is because we restricted our sample to common support

Under three specifications regarding VPA, MPA and WALK, the standardized mean differences were less than 10 in all cases which suggested that our estimations passed the balancing test(PSM balance estimations are available from the authors upon request) (26).

Non-linear analysis of PA for SRHS
Given the fact that our response variable was coded on a discrete and ordinal scale, a non-linear model was especially desired under this context (27). For the robustness of the results, we carried on our analysis by using an ordered logit model with PSM method. The reason we did not continue with this non-linear model for FE method was because there is no simple transformation available that would purge the ordered response models from the individual fixed effect (27). And we could include the individual fixed effect unless we collapsed the 5 categorical responses into two classes and applied a binary logit model (27-29).

Table 3 presents the marginal effects at means of different levels of PA on SRHS using an ordered logit model with PSM method.

Table 3: Marginal effects at means of the impact of different levels of PA on individuals' SRHS using an ordered logit model with PSM method

Variable	Very good	Good	Fair	Poor	Very poor
VPA	0.017***	0.016***	-0.004**	-0.022***	-0.007***
	(3.17)	(3.16)	(-2.40)	(-3.19)	(-3.16)
MPA	0.019***	0.019***	-0.004***	-0.026***	-0.009***
	(3.98)	(3.90)	(-3.10)	(-3.87)	(-3.73)
WALK	0.010*	0.009	-0.001**	-0.013	-0.005
	(1.67)	(1.63)	(-1.98)	(-1.60)	(-1.56)

Notes: Z statistics in parentheses. * $P<0.1$ ** $P<0.05$ *** $P<0.01$

The results showed that VPA and MPA both significantly increased the probability of individuals reporting their SRHS as very good (1.7 pp and 1.9pp for VPA and MPA, respectively) and good (1.6pp and 1.9pp for VPA and MPA, respectively), where pp indicates percentage points. In addition, VPA and MPA significantly decreased the probability of individuals reporting their SRHS as fair (0.4pp for both VPA and MPA), poor (2.2pp and 2.6pp for VPA and MPA, respectively) and very poor (0.7pp and 0.9pp for VPA and MPA, respectively). It could be seen that MPA had a larger impact on SRHS comparing to VPA. However, the impact of WALK was not significant in the second (good), fourth (poor) and fifth (very) levels, and only marginally significant in the first (very good) level. This was consistent with our linear estimations that moderate-to-vigorous PA had a significant positive impact on individuals' SRHS.

Discussion

This paper presented novel findings on the impact of different levels of PA on the SRHS of Chinese adults with an average age of 61 years old. We found a strong evidence that moderate-to-vigorous PA significantly improved the SRHS among Chinese middle-aged and elderly adults between 0.078 to 0.158 units using various methods. After taking into consideration of the discrete feature of our response variable, moderate-to-vigorous PA significantly increased the probability of individuals reporting their SRHS as very good and good by 1.7-1.9pp and 1.6-1.9pp, respectively. In addition, moderate-to-vigorous PA significantly decreased the probability of individuals reporting their SRHS as fair, poor and very poor by 0.4pp, 2.2-2.6pp and 0.7-0.9pp, respectively. However, we did not find evidence that WALK significantly improved individuals' SRHS. Present results are consistent with previous literature where PA improved individuals' health status (11-14), especially high intensity of PA was associated with good health (15) and low all-cause mortality (16). For example, Humphreys et al (11) used sample from residents over 12 years old in Canada at the year 2005 and found a significant positive impact of PA, especially moderate PA, on individuals' health outcomes. Lechner (12) investigated the impact of leisure sports participation on health based on individual samples from Germany during the year 1984 to 2006 and found a positive effect of sports participation on health. Rasciute and Downward (13) investigated the impact of physical activities such as sports participation and active forms of transport on self-rated health using a three-year survey in England which was commenced in 2005 and a broadly positive effect upon health was found. Pawlowski et al (14) studied the children in Peru at the years 2002, 2006 and 2009 and also found similar positive impact of PA on health. Driediger et al (15) mentioned the importance of carrying out PA among Canada and Australia children in their opinion research. Samitz et al (16) conducted a systematic review on the similar topic and found risk reduction per unit of time

increase was largest for vigorous exercise. Previous research for developed countries (11-13, 15) and children (14) cannot be applied for adults in developing countries, because other than the variances of methods and survey periods, their economic level, health stock, sports involvement and physical education were also different (30, 31).

As stated before, there was still a scarcity of research for relating physical activity to health among middle-aged and elderly population in developing countries (32, 33). This study was the first longitudinal study which investigated the impact of different levels of PA on SRHS among this population. China, a developing and the most populated country in the world, was a good start to study developing country issues. Our results indicated that participating in PA is an important instrument to improve individuals' health. In addition, the intensities of PA play important roles. Individuals could benefit more from moderate-to-vigorous PA. One potential explanation for the different impacts of various levels of PA could be based on the previous studies where it was shown that participating in different intensities of PA were related to individuals' different levels of aerobic capacities (34) and amounts of insulin (35). The negligible impact of the low intensity PA, such as walking, on SRHS could due to the less requirements of physical effort. As also suggested by the UK National Health Service (NHS), middle-aged and elderly adults should do two types of physical activities: aerobic exercise and strength exercise (2, 3).

There are three main contributions of the present study. First, to the best of our knowledge, this was the first longitudinal study to analyze the impact of physical activities on health among middle-aged and elderly adults in a developing country. Second, relationships of different levels of physical activity (or intensities of physical efforts) to the health benefits were made. Third, a comprehensive longitudinal database CHARLS was used in the present study which allowed us to control for the presence of time-invariant effects by observing the same person before and after being involved in physical activities. Moreover, to avoid the effect of potential endogeneity between

physical activity and SRHS, propensity score method was employed in the present study (24).

The limitation of this study is the health status variable used in this study was self-reported, this might result to the reporting bias (36). We were not able to detect the impact of PA on objective health status indicators, for example, individuals' health information from the hospitals, due to data limitation. This kind of study is specially warranted in the future.

There are public health implications of this study. For example, with the increasing proportion of elder population in China (33), as well as in the world, a cheap and effective way to improve the health condition in the aging society is necessary. Our study not only offered the evidence that PA improves health status among middle-aged and elderly adults in China, but also presented the clear way of proceeding the health-related policy by emphasizing the benefits and importance of moderate-to-vigorous PA. Our recommendation is that the government should encourage people to involve in more moderate-to-vigorous physical activities, for example aerobics, as they are efficient ways to improve individuals' health status.

Conclusion

Moderate-to-vigorous physical activities significantly improve the individuals' self-rated health status in Chinese middle-aged and elderly adults. However, walking, a lower intensity of physical activity, has a very less impact on the improvement of self-rated health status.

Ethical considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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Conflicts of interests

The authors declare that there are no conflicts of interests.

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