

RESEARCH ARTICLE

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# Is economic environment associated with the physical activity levels and obesity in Chinese adults? A cross-sectional study of 30 regions in China

Mei Wang<sup>1\*</sup> , Xu Wen<sup>2</sup>, Yanfeng Zhang<sup>1</sup>, Chongmin Jiang<sup>1</sup> and Fubaihui Wang<sup>1</sup>

## Abstract

**Background:** Based on the 2014 survey of physical activity and physical fitness data of 20 – 69 year old Chinese, this study aims to investigate the relationship between economic development and people's physical activity in China.

**Methods:** A total of 43,389 adults from 30 different regions in mainland China were recruited. The GDP per capita of the 30 regions were determined based on the 2013 annual statistical report released by the national bureau of statistics of China and provincial level statistics bureaus. A questionnaire was used to determine the participants' exercise frequency, duration, and intensity.

**Results:** For the 30 regions surveyed, the correlation coefficients between GDP per capita and weekly activity were 0.23 for men and 0.15 for women. The correlation coefficients between GDP per capita and obesity rates were 0.52 for men and 0.39 for women.

**Conclusions:** Although people in economically advanced regions in China currently engage in more physical activities than those in less economically developed regions, overweight and obesity persist as serious problems.

**Keywords:** Economic environment, Physical activity, Obesity

## Background

Regular physical activity helps maintain general health and aids in preventing chronic diseases such as obesity, diabetes, and cardiovascular disease [1, 2]. However, the average weekly physical activity levels of Chinese adults decreased by 32% from 1991 to 2006. By 2006, only 13.2% and 8.4% male and female adults, respectively, regularly engage in physical activities [3]. Research has shown that in 2014, 14.7% adults above 20 years old exercise regularly (i.e., at least thrice per week for at least 30 min per session at moderate intensity). Thus, the manner in which the physical activity levels of Chinese adults can be increased is imperative to prevent chronic diseases and improve overall quality of life.

Researchers have long focused on the factors that affect people's physical activity levels. Early studies have explored individual factors such as gender, age, educational level, smoking status, socio-economic status, and self-efficiency [4, 5]. However, recent research has shifted focus from the interrelationships among multiple factors to the broad examination of environment, society, and policy. Environmental factors include physical, economic, political, and cultural environments. These factors can be studied at the micro- (family and school), meso- (community), and macro-levels (city and state) [6]. However, most studies have adapted the micro-level perspective, whereas comparatively few have addressed this issue on a macro-level [7, 8].

The economic environment is one of the most significant macro-level factors. Traditional economic theory identifies the economic status of a country or city through singular and broad-brush indicators such as GDP, GDP per capita, and household income, as well as

\* Correspondence: wangmei@ciss.cn

<sup>1</sup>China Institute of Sport Science, 11 Tiyuguan Road, Dongcheng District, Beijing 100061, People's Republic of China

Full list of author information is available at the end of the article



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Engel and Kyril coefficients. Economic progress provides citizens with the conditions for enhanced exercise opportunities, but it does not necessarily increase people's physical fitness levels.

Studies have identified the relationships between GDP and physical activity levels. Data from Europe have indicated the positive correlation between GDP and physical leisure activity levels of 27 EU countries [9]. Another study of 76 countries found that more economically advanced and urbanized countries have a greater population of citizens with insufficient exercise [10]. A further study of 38 countries also indicated that GDP is negatively correlated with the population's physical activity levels [11]. These varying results suggest the absence of a simple negative or positive correlation between economic environment and physical activity levels. This finding is attributed to the different types of physical activities (leisure physical activity versus overall physical activity) and countries studied (developing and developed countries).

Some research examined correlations of macro-level factors (such as GDP and unemployment rates) with body mass index (BMI) and obesity. Different regions and different economic statuses vary this correlation [12]. For example, one study showed that in countries with a GDP per capita of below USD 3000, GDP and BMI have a positive correlation ( $r = 0.567$ ). If the GDP per capita is over USD 3000, GDP and BMI showed no significant correlations [13].

China is a large country with immense variations between eastern and western regions and between urban and rural areas. Neither economic progress and status nor physical activity levels are uniform across the country. Research has shown that 28.9% of adults in rural areas participate in leisure exercise activities, whereas it is only 7.9% in urban areas [14]. The obesity rates across all age groups and regions in China increase at different rates [15]. Research that addresses the following questions: are regional variations between physical activity levels and obesity rates correlated with varying economic environments, and is economic progress associated with the people's physical activity levels, remain scant.

Based on the 2014 survey of physical activity and physical fitness data of 20 – 69 year old Chinese, this study analyzed the relationship between these data and regional economic status to provide nationally representative findings and to aid policy makers with evidence-based recommendations.

## Methods

### Participants

China, a country with a vast territory, has great geographic and economical differences among the eastern, central, and western regions and between the urban and rural areas. A complex, stratified, multistage probability cluster

sampling design was applied to recruit participants. In the current study, three provinces were randomly chosen from the eastern, central, and western regions of China. Beijing was also included in the survey because it is the capital. In summary, 10 provinces (autonomous region or municipality directly under the central government) were included in the study (Table 1 and Fig. 1). Three regions were extracted as (Categories I, II, and III) in each province according to economic development. Similar sampling methods were applied in some national physical activity and fitness survey in China, which were introduced in detail in a previous study [16]. In the 2010 national survey, Category I regions have a total population of 60.85 million, Category II has 42.85 million, and Category III has 22.93 million people. In 2013, the GDP per capita of Categories I, II, and III regions are CNY 94,812, 48,949, and 41,098, respectively. Great differences between the three category regions are evident. Informed consent was obtained from all participants before the test. The study was approved by the Ethics Committee of China Institute of Sport Science.

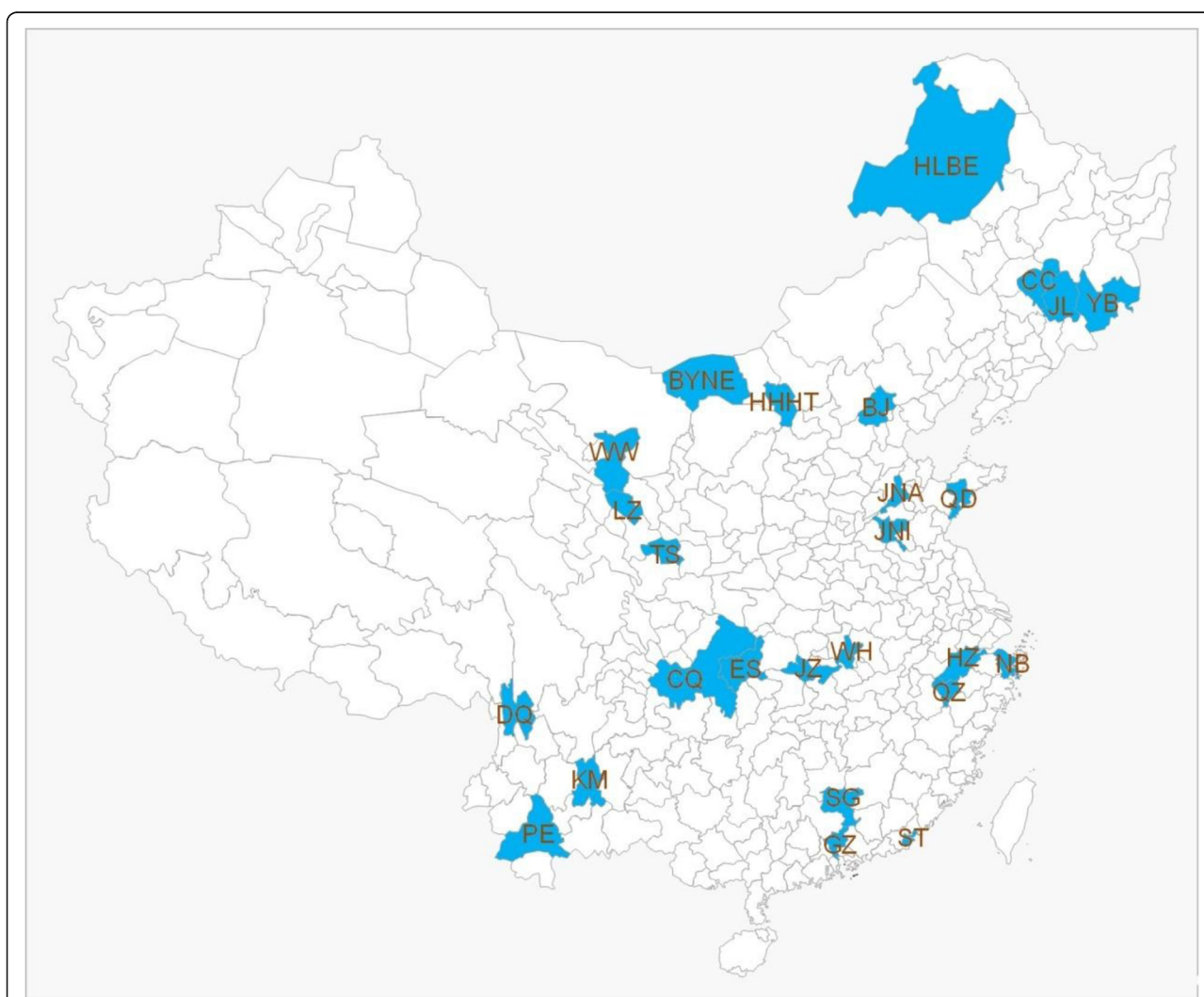
The participants were divided into three groups based on their age (20 – 39, 40 – 59, and 60 – 69 years old). A total of 43,389 adults were recruited, of which 15,464 (51.45% male and 48.55% female) were from Category I regions, 13,363 (51.17% male and 48.83% female) from Category II, and 14,562 (51.11% male and 48.80% female) from Category III (Table 2). Table 2 shows the sample distribution.

### Measurements

The National Bureau of Statistics of China and provincial level statistics bureaus released the 2013 annual statistical report, which contains the GDP per capita of the 30 regions. This data was used to indicate the economic development status of individual regions. A modified Godin-Shephard leisure-time physical activity questionnaire in Chinese was used to measure physical activity [17]. Validity and reliability tests were conducted before the survey, for which 52 Chinese adults were recruited. A total of 52 Chinese adults were invited to complete the questionnaire twice with 2 weeks apart to determine the 2-week test-retest reliability. In addition, 52 participants were invited to wear Actigraph accelerometer for 7 days. The 2-week test-retest reliability and correlation coefficient between counts measured by accelerometer and weekly leisure-time activity scores obtained by the questionnaire were 0.87 and 0.46. The participants' results were assessed against American College of Sports Medicine (ACSM) standards to determine whether they were getting sufficient exercise (i.e., 150 min moderate exercise per week) [18]. Following the manual of the Godin-Shephard leisure-time physical activity questionnaire, the weekly physical activity score was calculated

**Table 1** The 30 regions studied in the current study

Provinces and cities	Category I	Category II	Category III
Beijing (BJ)	Dongcheng (DF)	Changping (CP)	Fangshan (FS)
Guangdong (GF)	Guangzhou (GZ)	Shantou (ST)	Shaoguan (SG)
Zhejiang (ZJ)	Hangzhou (HZ)	Ningbo (NB)	Quzhou (QZ)
Hubei (HB)	Wuhan (WH)	Jinzhou (JZ)	Enshi (ES)
Shandong (SD)	Jinan (JN)	Qingdao (QD)	Jinin (JN)
Jilin (JL)	Changchun (CC)	Jilin (JL)	Yanbian (YB)
Chongqing (CQ)	Yubei (YB)	Yongchuan (YC)	Fengdu (FD)
Yunnan (YN)	Kunming (KM)	Pu'er (PE)	Diqing (DQ)
Inner Mongolia (IM)	Hohhot (HHHT)	Hulunbeier (HLBE)	Bayannaoer (BYNE)
Gansu (GS)	Lanzhou (LZ)	Tianshui (TS)	Wuwei (WW)



**Fig. 1** The 30 regions studied in the current study

**Table 2** Basic information of the participants

Male				
	20-39 age group	40-59age group	60-69age group	Total
Category I	3851 (48.4%)	3328 (41.8%)	778 (9.8%)	7957 (100%)
Category II	3273 (47.9%)	2876 (42.1%)	690 (10.1%)	6839 (100%)
Category III	3532 (47.5%)	3142 (42.2%)	768 (10.3%)	7442 (100%)
Female				
	20-39 age group	40-59 age group	60-69 age group	Total
Category I	3664 (48.8%)	3082 (41.0%)	762 (10.1%)	7508 (100%)
Category II	3044 (46.7%)	2788 (42.7%)	693 (10.6%)	6525 (100%)
Category III	3340 (46.9%)	3037 (42.7%)	743 (10.4%)	7120 (100%)

as (9× weekly high-intensity exercise time) + (5× weekly moderate-intensity exercise time) + (3× weekly low-intensity exercise time) [17].

Each participant's body mass and height were measured by trained testers to calculate BMI, through dividing body mass (kg) by height in meters squared ( $m^2$ ). A BMI higher than  $24 \text{ kg}/m^2$  was regarded overweight, whereas a BMI higher than  $28 \text{ kg}/m^2$  was defined as obese [19].

Descriptive data were presented as mean and standard deviation. Chi-squared test was applied to compare the categorical variables. Logistic regression was used to calculate odd ratios of being physically inactive and obese in Categories I, II, and III regions. All statistical analyses were conducted using the SPSS 20.0 software program.

## Results

The findings showed that the majority of participants surveyed failed to sufficiently exercise. The number of participants who reached the adequate amount of 150 min of moderate physical activity per week was 19.2% for males and 21.0% for females. The comparison results of the BMI and physical activity scores showed that participants from Category I regions have increased physical activity levels and weights than their counterparts in Categories II and III regions (Table 3). The findings presented great regional variations in physical activity levels. Regardless of gender and age groups, Category I regions showed a higher ratio of participants

who engaged in adequate amounts of physical activity compared to Categories II and III regions. In most age groups, Category II participants have increased ratios of adequate physical activity levels than Category III participants. Within the 20 – 39 age group, men have a higher ratio of adequate physical activity compared with women, whereas women performed better than men in the 40 – 59 and the 60 – 69 age groups.

The enthusiasm of Chinese citizens toward physical activity increased with age. Only 16.2% of male participants aged 20 – 39 reached the adequate activity levels, with females at 13.2%. In the 40 – 59 age group, males and females achieved 20.2% and 26.1%, respectively. Participants from the 60 – 69 age group obtained 29.2% and 35.2% for males and females, respectively (Table 4).

Within the 30 regions surveyed, the correlation between GDP per capita and weekly activity levels in males was  $r = 0.23$  and  $r = 0.15$  in females (Fig. 1). Compared with Categories II and III, the participants in Category I have higher tendencies to not reach adequate activity levels (Category II was 55% more likely than Category I, and Category III was 71% more likely). Category III participants were 11% more likely to not reach adequate activity levels compared with Category II (Fig. 2 and Table 5).

Table 6 shows the status of the overweight participants in the survey. Over half of the males and more than 40% of the females were considered overweight. Across all age groups, Category I participants indicates

**Table 3** Comparison of basic information of the participants (mean ± SD)

		Category I	Category II	Category III	Sig.
GDP per capital (CNY)		94,811.7 ± 38,694.3	48,948.6 ± 28,553.5	41,098.2 ± 24,704.3	$P < 0.01$
Men	Age (y)	40.8 ± 13.1	40.9 ± 13.1	41.1 ± 13.1	$p > 0.05$
	BMI ( $\text{kg}/m^2$ )	24.7 ± 3.5	24.2 ± 3.4	24.2 ± 3.4	$P < 0.01$
	PA score	62.8 ± 43.8	60.3 ± 43.8	55.2 ± 43.6	$P < 0.01$
Women	Age (y)	40.9 ± 13.2	41.4 ± 13.1	41.1 ± 13.0	$p > 0.05$
	BMI ( $\text{kg}/m^2$ )	23.7 ± 3.5	23.3 ± 3.5	23.3 ± 3.4	$P < 0.01$
	PA score	60.8 ± 41.3	58.4 ± 41.3	53.2 ± 41.8	$P < 0.01$

Note: BMI body mass index, PA physical activity

**Table 4** The number and percentages of participants who exercise more than 150 min per week

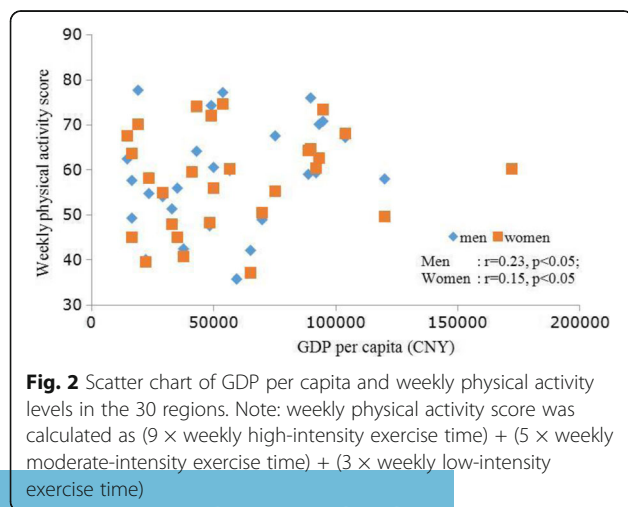
		Category I	Category II	Category III	Sum	P
Male	20-39 age group	711 (18.5%)	463 (14.2%)	539 (15.4%)	1713 (16.2%)	$P < 0.01$
	40-59 age group	859 (25.8%)	546 (19.1%)	480 (15.3%)	1885 (20.2%)	$P < 0.01$
	60-69 age group	309 (38.8%)	190 (26.4%)	178 (22.3%)	677 (29.2%)	$P < 0.01$
	Sum	1879 (23.6%)	1199 (17.5%)	1197 (16.1%)	4275 (19.2%)	$P < 0.01$
Female	20-39 age group	608 (16.7%)	309 (10.2%)	402 (12.1%)	1319 (13.2%)	$P < 0.01$
	40-59 age group	1031 (33.4%)	666 (23.9%)	620 (20.6%)	2317 (26.1%)	$P < 0.01$
	60-69 age group	361 (46.1%)	247 (34.1%)	199 (25.3%)	807 (35.2%)	$P < 0.01$
	Sum	2000 (26.6%)	1222 (18.7%)	1221 (17.2%)	4443 (21.0%)	$P < 0.01$

Note: GDP per capita: Category I > Category II > Category III

a higher ratio of overweight participants compared with Categories II and III. This trend showed statistical significance in every measurement group except in 60 – 69 females, where the differences were insignificant.

Table 7 presents the status of obesity in the participants surveyed, in which 14.8% of males and 10.5% of females were considered obese. Among the males, the 20 – 39 and 40 – 59 age groups reported higher ratios of obesity than the 60 – 69 age group. In females, the 20 – 39 age group showed significantly less obesity ratios compared with older age groups. Category I obesity rates were significantly higher than those of Categories II and Category III. In the 60 – 69 age group, no significant difference was found among the three Categories.

Figure 3 shows the correlation between GDP per capita and obesity rates ( $r = 0.52$  for males and  $r = 0.39$  for females). Using logistic regression, Categories II and III regions exhibited lower risks of obesity (0.78 and 0.73, respectively) compared with Category I regions. No significant difference was found in risk of obesity between Categories II and III regions (Fig. 3 and Table 8).



## Discussion

This study is one of the few nationwide, evidence-based research studies on the macro-level correlation among economic environment and physical activity and obesity/overweight levels of Chinese adults. Despite the Chinese government's encouragement for people to engage in increased physical activities through the 1995 "National Fitness Plan", the current physical activity levels among the population 20 years later remain inadequate. This study showed that only approximately 20% of Chinese adults obtain the adequate amount of physical activity per week (150 min at moderate intensity). Younger Chinese adults are far less active than older adults (with the share of active adults in the 20 – 39 age group at 16.2% for males and 13.2% for females compared with the share of active adults in the 60 – 69 age group at 29.2% for males and 35.2% for females). This disparity can be explained by the fact that elderly Chinese have more leisure time to participate in physical activity after retirement. Nevertheless, this finding calls for urgent and radical action to promote and increase future physical activity levels in the country.

The current study found that the ratio of people achieving adequate physical activity levels is higher in Category I regions than in Categories II or III regions. Furthermore, a weak positive correlation between GDP per capita and total amount of physical activity was found. This result is in accordance with European findings, in which data were collected from 27 European member states, and leisure time physical activity was found to be significantly associated with GDP and real

**Table 5** The odds ratio of being physical inactive in different regions compared with reference regions

Reference regions	Targeted regions	OR
Category I	Category II	1.55 (95%CI:1.46-1.64)
Category I	Category III	1.71 (95%CI:1.62-1.81)
Category II	Category III	1.11 (95%CI:1.05-1.18)

Note: OR Odds Ratio; 95%CI:95% Confidence Interval

Age and gender were adjusted in the analysis

Note: GDP per capita: Category I > Category II > Category III

**Table 6** The number and percentages of overweight participants

		Category I	Category II	Category III	Total	P
Male	20-39 age group	1707 (53.9%)	1221 (47.2%)	1293 (46.3%)	4221 (49.4%)	$P < 0.01$
	40-59 age group	1636 (61.5%)	1257 (55.9%)	1310 (56.7%)	4203 (58.2%)	$P < 0.01$
	60-69 age group	379 (53.5%)	275 (47.8%)	291 (45.4%)	945 (48.8%)	$P < 0.05$
	Sum	3722 (56.8%)	2753 (50.9%)	2894 (50.4%)	9369 (52.9%)	$P < 0.01$
Female	20-39 age group	889 (30.1%)	579 (24.0%)	665 (26.6%)	2133 (27.1%)	$P < 0.01$
	40-59 age group	1281 (54.5%)	1085 (50.4%)	1131 (52.1%)	3497 (52.4%)	$P < 0.05$
	60-69 age group	400 (59.3%)	320 (57.7%)	305 (55.2%)	1025 (57.5%)	$P > 0.05$
	Sum	2570 (43.0%)	1985 (38.7%)	2101 (40.2%)	6656 (40.8%)	$P < 0.01$

Note:  $BMI \geq 24 \text{ kg/m}^2$  was defined as overweight

GDP per capita: Category I > Category II > Category III

GDP [9]. Thus, we can conclude from this finding that residents are more likely to engage in physical activities in better economic environments. However, some studies have reported a negative correlation between GDP and physical activity levels. Economic progress does not necessarily increase physical activity levels [10, 11]. This finding may be attributed to the development status of the countries studied. In developing countries experiencing slight economic progress and scientific and technological advancements, mechanized industrialization decrease the amount of occupational physical activity in the population. At this point, total physical activity is reduced, yet the population still fails to afford leisure physical activities. With further economic progress resulting in less working hours and more disposable income, people can increase their leisure physical activities. After 30 years of economic reform, China's overall economic status dramatically increased. In the more economically advanced big regions and the Eastern region, people have more opportunities and financial capabilities to engage in leisure physical activities compared with those in less economically developed regions and rural regions. China's current economic status supports the results of this study on the weak positive correlation between GDP per capita and physical activity levels.

Obesity and overweight has become serious public health issues in China. This study found that over half of the male population is overweight (among them 15% are considered obese) and over 40% of the females are overweight (among them 10% are considered obese). This study showed that although Category I participants spent more time on physical activities, the obesity and overweight ratio remained higher than that of Categories II and III regions. Previous research has found that when GDP per capita is over USD 3000, no significant correlation is observed between GDP and obesity rates. Most of the regions investigated in the present study have a GDP per capita of over USD 3000. Despite this condition, the current study observed a positive correlation between GDP and BMI and obesity rates. This finding suggests that as a country experiences economic growth, its obesity rates also increases. This result can be attributed to the higher caloric intake of people living in economically advanced regions than their poorer, rural counterparts.

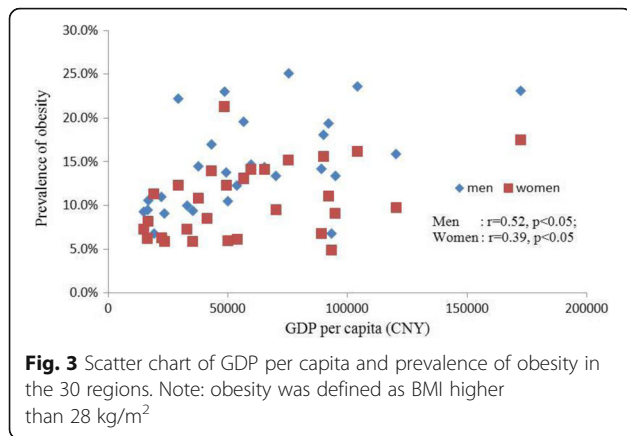
The relation between economic progress and obesity rate has attracted much interest in recent years. People believe that obesity and overweight are diseases of affluence [20]. Higher income leads to greater food supply and caloric intake, as well as lowered physical activity. This trend is noted in countries with poor economic

**Table 7** The number and percentages of obese participants

		Category I	Category II	Category III	Total	P
Male	20-39 age group	584 (18.4%)	374 (14.5%)	362 (13.0%)	1320 (15.4%)	0.000
	40-59 age group	477 (17.9%)	297 (13.2%)	311 (13.5%)	1085 (15.0%)	0.000
	60-69 age group	85 (11.8%)	61 (10.6%)	64 (10.0%)	210 (10.8%)	0.565
	Sum	1146 (17.5%)	732 (13.5%)	736 (12.8%)	2614 (14.8%)	0.000
Female	20-39 age group	232 (7.9%)	144 (6.0%)	130 (5.2%)	506 (6.4%)	0.000
	40-59 age group	356 (15.1%)	282 (13.1%)	284 (13.1%)	922 (13.8%)	0.068
	60-69 age group	118 (17.5%)	92 (16.6%)	82 (14.8%)	292 (16.4%)	0.443
	Sum	706 (11.8%)	518 (10.1%)	496 (9.5%)	1720 (10.5%)	0.000

Note:  $BMI \geq 28 \text{ kg/m}^2$  was defined as obesity

GDP per capita: Category I > Category II > Category III



environments. In more economically developed countries, the BMI of females in high socio-economic groups are actually lower than females in low income groups [21]. This finding can be attributed to low income families opting for cheap processed foods with high sugar and energy content as opposed to more expensive fresh food such as fruits and vegetables. Hence, people in lower socio-economic groups are more at risk of obesity and overweight due to increased caloric intake [22]. Cross-sectional studies have shown that in low-income countries, obesity rates increase with economic progress, whereas in medium-income countries, obesity rates and economic progress are slightly negatively correlated; furthermore, a negative correlation between income and body weight (especially among women) is noted in high-income developed countries [20]. Economically, China is currently moving from a low-to a medium-income developing country. This movement can explain the higher rates of obesity in more economically advanced Category I regions as opposed to Categories II and III regions.

However, some recent longitudinal studies have exhibited inconsistent results. Early studies have shown that during periods of economic decline and financial depression, the people’s mental stress levels increase, families break down, and people take on unhealthy habits, which increased mental illness. Consequently, deaths due to cardiovascular disease and suicide increase. By contrast, during periods of accelerated economic progress, stress and intensity from work increased, as is the amount of

working hours. These conditions take time and attention away from physical exercise, there by taking a toll on health [23]. In recent years, studies that have focused on periods of economic decline showed that the overall BMI of populations also decrease. This trend is observed in various income demographics. These results are inconsistent with the trends mentioned before [24]. Hence, increased research is necessary to elucidate the relationships among economic environment, obesity rates, and physical activity levels.

The advantage of the current study is its relatively large sample size and it can be representative of China’s overall situation. The results reflect China’s current inadequacies in terms of economic progress, obesity rates, and physical activity levels, and more importantly, the relationships among these three factors. This study is limited by its cross-sectional nature; thus, it failed to make conclusions about cause and effect over time and to conduct in-depth investigations into the mechanisms of these interrelationships.

**Conclusion**

At present, although people in economically advanced regions in China engage in more physical activities than those in less economically developed regions, the problems of overweight and obesity persist as serious issues requiring immediate action.

**Acknowledgements**

None.

**Funding**

This study was supported by the research fund of 2014 physical activity and physical fitness survey in 20-69 years old Chinese from general Administration of Sport of China.

**Availability of data and materials**

The data support this study came from 2014 physical activity and physical fitness survey in 20-69 years old Chinese conducted by China physical fitness surveillance Centre. The raw data is confidential and not publicly available. Data may be shared with researchers obtaining permissions from China physical fitness surveillance Centre.

**Authors’ contributions**

MW, YFZ conceived the idea for the study, procured the funding and drafted the paper. XW was involved in both the data analyses and drafted the paper. CMJ and FBHW contributed to design the study and fieldwork coordination. All authors read and approved the final manuscript.

**Ethics approval and consent to participate**

The aims and objectives of the study was introduced to each participant and written consent from all the participants were obtained before the test. The study was approved by the Ethics Committee of China Institute of Sport Science.

**Consent for publication**

Not applicable.

**Competing interests**

The authors declare that they have no competing interests.

**Table 8** The odds ratio being obese in adults in different regions compared with reference regions

Reference regions	Targeted regions	OR
Category I	Category II	0.78 (95%CI: 0.72-0.84)
Category I	Category III	0.73 (95%CI: 0.68-0.79)
Category II	Category III	0.94 (95%CI: 0.87-1.02)

Note: OR: Odds Ratio; 95%CI:95% Confidence Interval  
Age and gender were adjusted in the analysis  
GDP per capita: Category I > Category II > Category III

## Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

## Author details

<sup>1</sup>China Institute of Sport Science, 11 Tiyyuguan Road, Dongcheng District, Beijing 100061, People's Republic of China. <sup>2</sup>Department of Physical Education, College of Education, Zhejiang University, Hangzhou, People's Republic of China.

Received: 10 May 2017 Accepted: 29 August 2017

Published online: 12 September 2017

## References

- Bell JA, Hamer M, van Hees VT, Singh-Manoux A, Kivimaki M, Sabia S. Healthy obesity and objective physical activity. *Am J Clin Nutr*. 2015;102(2):268–75.
- Fan S, Chen J, Huang J, Li Y, Zhao L, Liu X, Li J, Cao J, Yu L, Deng Y, et al. Physical activity level and incident type 2 diabetes among Chinese adults. *Med Sci Sports Exerc*. 2015;47(4):751–6.
- Ng SW, Norton EC, Popkin BM. Why have physical activity levels declined among Chinese adults? Findings from the 1991 - 2006 China health and nutrition surveys. *Soc Sci Med*. 2009;68(7):1305–14.
- Craggs C, Corder K, Sluijs EMFV, Griffin SJ. Determinants of change in physical activity in children and adolescents. *Am J Prev Med*. 2011;40(6):645–58.
- Trost SG, Owen N, Bauman AE, Sallis JF, Brown W. Correlates of adults' participation in physical activity: review and update. *Med Sci Sports Exerc*. 2002;34(12):1996–2001.
- Swinburn B, Egger G, Raza F. Dissecting obesogenic environments: the development and application of a framework for identifying and prioritizing environmental interventions for obesity. *Prev Med*. 1999;29(6):563–70.
- Ferreira I, Horst KVD, Wendel-Vos W, Kremers S, Lenthe FJV, Brug J. Environmental correlates of physical activity in youth -a review and update. *Obes Rev*. 2007;8(2):129–54.
- Rabin BA, Boehmer TK, Brownson RC. Cross-national comparison of environmental and policy correlates of obesity in Europe. *Eur J Pub Health*. 2007;17(1):53–61.
- Van Tuyckom C. Macro-environmental factors associated with leisure-time physical activity: a cross-national analysis of EU countries. *Scand J Public Health*. 2011;39(4):419–26.
- Dumith SC, Hallal PC, Reis RS, Kohl HW 3rd. Worldwide prevalence of physical inactivity and its association with human development index in 76 countries. *Prev Med*. 2011;53(1-2):24–8.
- Bosdriesz JR, Witvliet MI, Visscher TL, Kunst AE. The influence of the macro-environment on physical activity: a multilevel analysis of 38 countries worldwide. *Int J Behav Nutr Phys Act*. 2012;9:110.
- Zhang Q, Lamichhane R, Wang Y. Associations between U.S. adult obesity and state and county economic conditions in the recession. *J Clin Med*. 2014;3(1):153–66.
- Egger G, Swinburn B, Islam FM. Economic growth and obesity: an interesting relationship with world-wide implications. *Econ Human Biol*. 2012;10(2):147–53.
- Muntner P, Gu D, Wildman RP, Chen J, Qan W, Whelton P, He J. Prevalence of physical activity among Chinese adults: results from the international collaborative study of cardiovascular disease in Asia. *Am J Public Health*. 2005;120(95):1631–6.
- Wang Y, Mi J, Shan XY, Wang QJ, Ge KY. Is China facing an obesity epidemic and the consequences? The trends in obesity and chronic disease in China. *Int J Obes*. 2007;31(1):177–88.
- Tian Y, Jiang C, Wang M, Cai R, Zhang Y, He Z, Wang H, Wu D, Wang F, Liu X, et al. BMI, leisure-time physical activity, and physical fitness in adults in China: results from a series of national surveys, 2000-14. *Lancet Diabetes Endocrinol*. 2016;4(6):487–97.
- Godin G. The Godin-Shephard leisure-time physical activity questionnaire. *Health Fitness J Canada*. 2011;4(1):18–22.
- Haskell WL, Lee IM, Pate RR, Powell KE, Blair SN, Franklin BA, Macera CA, Heath GW, Thompson PD, Bauman A. Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Med Sci Sports Exerc*. 2007;39(8):1423–34.
- Zhou BF, Cooperative Meta-Analysis Group of the Working Group on Obesity in China. Predictive values of body mass index and waist circumference for risk factors of certain related diseases in Chinese adults—study on optimal cut-off points of body mass index and waist circumference in Chinese adults. *Biomed Environ Sci*. 2002;15(1):83–96.
- Ezzati M, Hoom SV, Lawes CMM, Leach R, James WPT, Lopez AD, Rodgers A, Murray CJL. Rethinking the “diseases of affluence” paradigm: global patterns of nutritional risks in relation to economic development. *PLoS Med*. 2005;2(2):404–12.
- Sobal J, Stunkard AJ. Socioeconomic status and obesity: a review of the literature. *Psychol Bull*. 1989;105(2):260–75.
- Monsivais P, Drewnowski A. Lower-energy-density diets are associated with higher monetary costs per kilocalorie and are consumed by women of higher socioeconomic status. *J Am Diet Assoc*. 2009;109(5):814–22.
- Harvey Brenner M. Mortality and the national economy. *Lancet*. 1979; 314(8142):568–73.
- Hruschka DJ. Do economic constraints on food choice make people fat? A critical review of two hypotheses for the poverty-obesity paradox. *Am J Hum Biol*. 2012;24(3):277–85.

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