Depression, Physical activity, and self-rated health: Panel analysis of adults in South Korea

Hee-sang Yoon (✉ viva826@snjc.ac.kr)

Research article

Keywords: self-rated health (SRH), socioeconomic factors, depression, walking, data analysis

Posted Date: March 2nd, 2020

DOI: <https://doi.org/10.21203/rs.3.rs-15598/v1>

License: © ⓘ This work is licensed under a Creative Commons Attribution 4.0 International License. [Read Full License](#)

Abstract

Background: The health status of an individual is determined by socio-economic factors and behavioral factors. Socio-economic factors include marital status, educational level, living expenses, and housing type, among others. The differences of health status across individuals are mainly determined by these socioeconomic factors, which cannot be altered in a short run. However, even if the socioeconomic factors cannot be altered in the short run, there are ways for an individual to improve the health status in a relatively short period of time. These are behavioral factors, such as physical activities and management of depression.

Methods: We provided evidence of the first statement by running a pooled OLS regression with self-rated health (SRH) as dependent variable and with walking, management of depression, sex, age, marital status, educational level, housing type, living expenses, and economic activity as independent variables. We proved the second statement by running a fixed-effect panel regression with the same dependent and independent variables. The 2010–2013 Korea Health Panel Survey data were used for analysis. Subjects were 34,436 adults (≥ 19 years) in 8,609 panel groups.

Results: All the variables, including socio-economic variables as well as behavioral variables, were significant in the Pooled OLS regression. Whereas behavioral variables, such as walking and management of depression, were significant in the fixed-effect panel regression, socio-economic variables were not. The reason is that socio-economic variables are stable and not variant for an individual in the short-run.

Conclusion: Whereas the differences of health status across individuals are mainly determined by socioeconomic factors, the health of an individual is significantly affected by his/her behavior. It is shown that regular walking and reduction of depression are important in improving SRH. There is a need for strategies designed to address depression and aging and encourage walking.

Background

The health status of an individual is determined by socio-economic factors and behavioral factors. Socio-economic factors include marital status, educational level, living expenses, and housing type, among others. The differences of health status across individuals are mainly determined by these socioeconomic factors, which cannot be altered in a short run. However, even if the socioeconomic factors cannot be altered in the short run, there are ways for an individual to improve the health status in a relatively short period of time. These are behavioral factors, such as physical activities and management of depression.

Self-rated health (SRH) is commonly used as a key indicator for identifying changes in individual health status [1, 2]. SRH is a subjective assessment of an individual's physical and mental health status over time, i.e., an indicator of perceived health [3–5]. As a predictor of the prevalence of various chronic diseases and related mortality risk, SRH is widely used worldwide as an objective indicator to estimate the health status of the population [2–5].

SRH is related to socioeconomic factors such as age, gender, educational level, standard of living, and economic activities [6], and emotional states and health-related lifestyle [6–7]. Obesity is a factor affecting health status, as obese people tend to have lower SRH scores [8–9]. Physical activity is another factor influencing health status [4, 6, 9], and little or no physical activity can lead to premature death [10]. Walking is a typical physical activity that

can be practiced even at an advanced age and is good regardless of the speed and method used [11–13]. Regular walking reduces risk of metabolic and chronic diseases, and boosts SRH [11]. Depression is an important determinant of health status, and people with depression often complain of chronic illnesses and have low SRH scores [6, 7, 14, 15].

Despite the availability of studies on depression and physical activity in relation to SRH in many countries, most of them rely on cross-sectional survey data [1, 5–7], showing limitations in identifying the cause-effect relationship [2, 8, 16].

The objective of this research is to show that the differences of health status across individuals are mainly determined by socioeconomic factors that cannot be altered in the short run, by running a pooled ordinary least square (OLS) regression model with self-rated health (SRH) as dependent variable and with socioeconomic factors as independent variables. Then, by running a fixed-effects (FE) panel regression model with the same dependent and independent variables, we proved that an individual can improve the health status in the short run by physical activity, such as walking, and by management of depression.

Methods

Study Design

This descriptive study aimed to determine the factors affecting SRH in the adult population (aged ≥ 19 years) in South Korea by performing secondary analysis based on the 2010–2013 Korea Health Panel Survey (KHPS) data.

Subjects and Data Collection

The data used in this study were drawn from the KHPS database jointly developed by the National Health Insurance Corporation of Korea and the Korea Institute for Health and Social Affairs. The representativeness of the KHPS was ensured by its sampling frame accounting for 90% of the complete enumeration data of the 2005 Population and Housing Census. Households were selected from sampling units through a two-stage sampling procedure consisting of cluster sampling and proportionate stratified random sampling. All selected households were visited by technical researchers for computer-aided personal interviewing (CAPI). For analysis purposes, we obtained anonymized KHPS data after receiving the approval from the Korea Institute for Health and Social Affairs as per data use agreement. This study was granted a waiver of review by the Institutional Review Board of Seoul women's College of Nursing.

This study used four waves of KHPS data (2010–2013) for analysis. The subjects were adults aged 19 and over. From a total of 51,217 initial subjects, 34,436 subjects in 8,609 panel groups were included for analysis after excluding missing values for independent and dependent variables. The panel data set was strongly balanced (14,192 males in 3,548 panel groups; 20,244 females in 5,061 panel groups).

Variables

Although SRH is usually rated on a 5-point scale, this study used a graduated measurement to report SRH on a scale of 0 (worst health status) to 100 (best health status). SRH, the dependent variable, is a subjective health

status assessment item in the health panel survey data. Respondents provided their answer to the question “How would you rate the current status of your own health?” on a 100-point scale.

Independent variables were body mass index (BMI), walking, and depression. BMI was calculated with the formula “weight (kg) / [height (m)]²” based on the height and weight entered for items 1 and 2 of the health-related lifestyle questionnaires.

Walking was used as a representative variable of physical activity. For this variable, items 3 (walking) and 3 – 1 (duration) of the physical activity questionnaire were used. Respondents were asked to select from one to seven, in response to item 3 question “How many days have you walked more than 10 minutes last week?” They were asked to choose one of six duration ranges in response to item 3 – 1 question “How many minutes did you walk if you walked at least 10 minutes?”: less than 20 minutes, 20–29 minutes, 30–39 minutes, 40–49 minutes, 50–59 minutes, and 60 minutes or longer. Using the number of days and walking duration, the weekly mean time spent on walking was calculated by multiplying the number of days by 15, 25, 35, 45, 55, or 65 for the 6 duration ranges, respectively. In a systematic review regarding the health-related effects of walking, the total walking duration was calculated on a minute/week basis, using the mean or median values for the walking duration given for the ranges [17].

For depression, we asked “Have you ever felt sad or desperate to the extent that it affected your daily life for 2 consecutive weeks or longer during the past 12 months?” to which the respondents were supposed to answer 1. Yes, or 2. No.

The general characteristics were sex, age, marital status, educational level, housing type, living expenses, and economic activity. The questions and responses regarding each of these variables were as follows: “What is your gender?” – 1. Male, 2. Female; “What is your date of birth?” – the date of birth as recorded on the resident registration card (used for the calculation of the age in the survey year); “What is your marital status?” – 1. Married (including civil union), 2. Separated (including informal divorce), 3. Widowed/Missing, 4. Divorced, 5. Unmarried (for the analysis, responses 2–4 were categorized as “Others”); “What is your highest completed education or what are you currently enrolled in?” – No schooling, Elementary school (grades 1–6), Middle school (years 1–3), High school (years 1–3), University/Junior college (years 1–6), Master’s degree, and PhD (for the analysis, the number of years of schooling or education was categorized as 0 [no schooling] and over 21 years [PhD]); “What is your housing type?” – 1. Owned, 2. Rent (long-term), 3. Rented (short-term), 4. Rent-free dwelling (provided by the government or employer), 5. Free dwelling (provided by parents, relatives, children, friends, etc.), 6. Others (For analysis, answers 4–6 were categorized as “Others”); “How much money do you need each month to meet your living expenses?” – the amount of money paid for food, housing type, clothing, education, healthcare, and utilities, savings excluded; “Have you held a paying job (including temporary unemployment)?” – 1. Yes, 2. No.

Data Analysis

The 2010–2013 KHPS data were used for analysis. Most of the variables explain before, such as walking, marital status, housing type, were used as independent variables. However, management of depression was used as independent variable, instead of depression. Management of depression takes the value of 1 when there is no depression and 0 when there is depression.

Analysis was performed using STATA version 14.2. Statistical significance was considered when $p < 0.05$. The extracted data were analyzed using pooled OLS regression model and FE panel regression model [18]. Pooled OLS regression model was used to analyze the effects of socioeconomic factors on health status across individuals. As most of the socioeconomic variables are quite stable for an adult, the variation of these explains the difference of health status across individuals. As all of these variations across individuals disappear in fixed effect panel regression model, we can analyze the effects of physical activities and management of depression, which are more varying in the short-run, on the health status of an individual.

Analysis Models

Pooled OLS Regression Model

Since the subjects in this study are adults (≥ 19 years), most of the socioeconomic characteristics do not undergo significant intra-individual variations during the 4-year panel survey period. In fact, there were little changes in the following general subject characteristics during this period within the panel groups: educational level (within standard deviation [SD] = 0.26), living expenses (within SD = 59.04), housing type (within percent = 90.9 for “Owned”), marital status (within percent = 98.0 for “Married”), and economic activity (within percent = 84.3 for “Yes”). The pooled OLS regression was performed to analyze the effects of socioeconomic variables on the health status across individuals.

In the first step, the following pooled OLS model was used:

$$SRH_{it} = \alpha + BM_{it} + walking_{it} + mdepression_{it} + age_{it} + sex_{it} + marital\ status_{it} + educational\ level_{it} + housing\ type_{it} + living\ expenses_{it} + economic\ activity_{it} + \varepsilon_{it}$$

SRH_{it} is self-rated health of an individual i at time t .

Fixed-Effects (FE) Panel Regression Model

In the second step, the following FE regression model was used:

$$SRH_{it} = \alpha + BMI_{it} + walking_{it} + mdepression_{it} + age_{it} + marital\ status_{it} + educational\ level_{it} + housing\ type_{it} + living\ expenses_{it} + economic\ activity_{it} + \mu_i + \varepsilon_{it}$$

In the FE panel regression model, all the time invariant individual characteristics are absorbed by the fixed effect. As most of the socioeconomic factors are not changing very much across the time, they may lose significance, and only time variant factors, such as walking, may keep the explanatory power.

Results

Subject Characteristics

The mean SRH score was 70.52 ± 15.67 , with men scoring higher than women (72.12 ± 15.05 vs. 69.39 ± 15.99). The mean BMI was 23.19 ± 3.06 , slightly higher among men compared with women (23.59 ± 2.85 vs. 22.92 ± 3.18). The mean walking duration was 143.18 ± 142.43 , and men walked more than women (147.39 ± 147.89 vs. 140.22 ± 138.40).

On average, 7.7% of respondents were found to have no management of depression. During the survey period, 34.6% of men and 36.9% of women felt continuously or sporadically depressed. Of respondents, 60.8% provided responses on economic activity experience (77.1% of men and 49.4% of women performed economic activity). Overall, 76.8% of the respondents were married, of which 98.0% remained married during the survey period. The proportion of housing type was 71.3%, and 90.9% chose the answer "Owned" during the survey period. The mean number of years of schooling was calculated to be 10.83 years, which remained constant during the survey period (within SD = 0.26) (Table 1).

Pooled ordinary least squares (OLS) Regression

The pooled OLS regression shows that most of the independent variables, including walking, management of depression, age, gender, educational level, marital status, housing type, living expenses, and economic activity, are important in explaining SRH (Table 2). Socioeconomic factors, such as marital status, educational level, housing type, living expenses, are all very important to explain the difference of health status across individuals. As these variables are stable across time for an individual but very different across individuals, we can know that these factors explain the difference of health status across individuals and not the change of health status across time for an individual.

From the regression we can know that behavioral factors, such as walking and management of depression, have also strong explanatory power. As these factors are varying across time, we can know that these variables explain not only the cross individual difference in health status but also the change of health status of an individual across time. To analyze how much these variables explain the change of an individual health status, we use the fixed effect panel regression model.

FE Regression

The FE regression shows that most of the socioeconomic variables lose significance, implying that, in the short run, an individual cannot rely on socioeconomic factors to improve the health in the short run. This is because, in this dataset, the socioeconomic variables are stable for an individual across the 4 years covered by the survey. Nevertheless, there are variables that affect the health status of an individual: walking, management of depression, and age. This means that an individual can improve the health in relatively short period of time by changing the lifestyle or behavior. If an individual can management of depression, the SRH would increase by 5.6 points. Those who walked more can have significantly better SRH than those who walked less (Table 3).

Discussion

In the pooled OLS regression model, socioeconomic variables, such as marital status, housing type, educational level, living expenses, and economic activity, as well as behavioral variables, such as walking and management of depression, were not significant in explaining SRH. In the FE panel regression model, only the behavioral variables maintained the power to explain SRH. This difference in the result between the FE panel regression and pooled OLS regression models could be attributable to the stability of the variables. Specifically, the difference could have been due to the fact that the general characteristics, such as marital status, educational level, housing type, living expenses, and economic activity, do not undergo significant intra-individual variability during the survey period. Pheiffer [19] observed that many risk factors for NCDs were not captured in FE regression analysis

and noted that important variables can be excluded from analysis by using certain panel analysis methods, leading to distorted results [20, 21].

The implication is that even if an individual cannot alter the socioeconomic status, he can still improve his health by changing the lifestyle. Many studies verified walking, depression, and age as variables affecting SRH [11, 17, 22, 23]. Depression has a negative effect on SRH [6, 14], and is an important predictor of SRH [15, 24, 25]. In our study as well, depression was found to have negatively affected SRH in both men and women. Whereas depression was found to be more prevalent in women than in men, men with depression tended to have poorer SRH than women with depression. On a related note, depression was found to lead to poorer SRH by reducing physical activity [14]. Depression is associated with socioeconomic features and lifestyle [6], and tends to cause SRH to drop through correlation with other variables [15, 24, 26]. In South Korea, 17.8% of older adults suffer from depression [25], older adults with depression have poor SRH and show high incidence of NCDs [27]. SRH is inversely proportionally related to depression [15], and regular walking mitigates against the severity of depression [6, 25, 28].

Walking has an overall positive effect; and increased walking was shown to contribute to enhanced self-perceived health [17]. In this study, we included all walking with a minimum duration of 10 min, regardless of speed, method, and purpose; for example, walking while commuting, walking at normal speed to and from a bus stop or subway station, and walking rapidly for exercise. This suggests that health can be improved just by walking and that regular walking is important to health [17, 19]. Walking improves health and reduces the risk of NCDs [1, 10, 29, 30]. Walking for 30 minutes every day was shown to improve health [28, 31]. Regular walking for more than 6 weeks improved SRH [17]. An intervention program of walking 30–60 minutes/week to change the sedentary lifestyle contributed to the narrowing of the health inequality gap [32] and the reduction of healthcare cost [9, 27].

The UK adopted new public health policies intended to promote walking as a commute mode [11, 33], and switching the commute mode from car to public transportation and walking was found to promote health by increasing physical activity [24, 34, 35]. It has been reported that people who commute on foot every weekday showed 45% higher physical activity, lower obesity rate [35, 36], and reduced NCDs risk [37].

In a study using British national panel data, Flint et al. [38] found that active commuting and walking to and from public transportation increases physical activity, which in turn reduces the healthcare burden of NCDs [39]. Even walking a short distance was found to positively influence SRH, BMI, and systolic and diastolic blood pressure [19]. Some longitudinal panel studies also verified the positive effects of regular walking on SRH [2, 17, 19, 38]. Given that 60.8% of the respondents of the present study were economically active, many of them can change their commute mode to public transport [11, 38], which can efficiently improve their SRH by offering various walking routes.

In the FE panel regression, BMI was not identified as an influential factor for SRH. During the study period, neither the intra-individual variations in obesity nor the effect of such variations on SRH were significant [20]. However, there is a need to analyze BMI in a longitudinal panel study, given that it is an important influential factor for SRH [9, 11, 22] and that it has been shown to affect SRH in separate analysis for men and women.

For comparison purposes, both pooled OLS and FE panel regressions were run in the current study. In general, panel data are analyzed with an FE regression which addresses the limitations of cross-sectional and time-series

analyses and considers attributes inherent to survey units [18]. However, since unobserved endogenous attributes are not always associated with observed attributes, a pooled OLS regression should be run on adult population data [20, 21, 24]. This is in line with the aforementioned finding that important variables that may influence a dependent variable cannot be identified if only an FE panel regression is run on panel data that undergo little change, leading to distorted results [20, 21]. Furthermore, since health-related variables such as SRH are affected by socioeconomic characteristics, a pooled OLS regression is often preferred when analyzing health-related panel data [20–22].

In the present study as well, socioeconomic variables were found to have no effects on SRH in the FE panel regression, whereas the pooled OLS regression, which included the socioeconomic variables identified marital status, housing type, educational level, living expenses, and economic activity as influential variables for SRH. Since these important variables affecting SRH, rarely show significant intra-individual variability, care should be taken to identify them by varying the analysis method [20, 21, 40, 41].

Limitations of this study included the fact that although four-waves of the KHPS data were used as the sampling frame representing the population average, analysis was performed only with variables presented in the raw data. The variable “walking” was analyzed based on the daily mean time spent walking for lack of the weekly mean. Additionally, whereas obesity is known to be an influential factor for SRH [10, 26, 38], no significant association was found in this study. This may be ascribed to the short data collection period (four waves of the KHPS data 2010–2013).

Conclusions

This study examined the association between socioeconomic factors and SRH using the pooled OLS and FE regression models. Walking, depression, age, sex, educational level, marital status, housing type, living expenses, and economic activity influenced SRH in the pooled OLS regression. Walking, depression, age and were found to influence SRH in the FE regression. This suggests the necessity of running a pooled OLS regression on all panel data when data characteristics undergo no significant intra-individual variations; whereas, panel data are usually analyzed with an FE regression model.

The results of this study highlight the necessity of working out interventions taking into account the socioeconomic characteristics affecting SRH. In view of the positive effects of walking on SRH and negative effects of depression and aging on SRH, there is a need to set up policy strategies designed to mitigate depression and encourage walking. Therefore, investigators of future research should consider socioeconomic factors in developing guidelines for physical activity.

Declarations

Ethics approval and consent to participate

This study was granted a waiver of review by the Institutional Review Board of Seoul Women’s College of Nursing (No. SWCN-201904-HR-003). The need for informed consent was waived by the Institutional Review Board of Seoul Women’s College of Nursing

Consent to publish

Not applicable

Availability of data and materials

The dataset we used for the research, detailed information on the survey design and characteristics are provided on the Korea Health Panel homepage (<https://www.khp.re.kr:444/web/data/data.do>).

Competing interests

The author declares that they have no competing interests.

Funding

The author did not receive any funding to conduct this study.

Author's contributions

HY conceptualized and designed the study, carried out the analyses, wrote the manuscript, and the manuscript submitted.

Acknowledgements

Not applicable.

Author information

Department of Nursing, Seoul Women's College of Nursing, Seoul, 03617, Korea

Abbreviations

BMI: body mass index; CAPI: computer-aided personal interviewing; FE: fixed-effects; KHPS: Korea Health Panel Survey; Mdepression: management of depression; NCDs: non communicable disease; OLS: ordinary least square; SRH: self-rated health

References

1. Teh JK, Tey LP, Ng ST. Ethnic and Gender Differentials in Non-Communicable Diseases and Self-Rated Health in Malaysia. *PLOS ONE*. 2014; 9: e91328.
2. Jylha M. What is self-rated health and why does it predict mortality? Towards a unified conceptual model. *Soc Sci Med*. 2009; 69: 307–316.
3. Idler EL, Benyamini Y. Self-rated health and mortality: a review of twenty-seven community studies. *J Health Soc Behav*. 1997; 38: 21–37.
4. Ford E, Bergmann MM, Boeing H, Li C, Capewell S. Healthy lifestyle behaviors and all-cause mortality among adults in the United States. *Prev Med*. 2012; 55: 23–27.
5. Nishi A, Kawachi I, Shirai K, Hirai H, Jeong S, Kondo K. Sex/Gender and Socioeconomic Differences in the Predictive Ability of Self-Rated Health for Mortality. *PLOS ONE*. 2012; 7: e30179.

6. Camargo-Casas S, Suarez-Monsalvel S, Zepeda MU, García-Peña C, Cano-Gutierrez CA. Multimorbidity, Depressive Symptoms, and Self-Reported Health in Older Adults: a Secondary Analysis of the Sabe Bogota Study. *Rev Invest Clin.* 2018; 70: 192-197.
7. Svedberg P, Bardage C, Sandin S, Pedersen NL. A prospective study of health, lifestyle and psycho social predictors of self-rated health. *Eur J Epidemiol.* 2006; 21: 767–776.
8. Fujii M, Oshio T, Shimizutani S. Self-Rated Health Status of the Japanese and Europeans in Later Life: Evidence from JSTAR and SHARE. *Japanese Economic Review.* 2014; 65: 483-498.
9. Davison KK, Ford ES, Cogswell ME, Dietz WH. Percentage of body fat and body mass index are associated with mobility limitations in people aged 70 and older from NHANES III. *J Am Geriatr Soc.* 2002; 50:1802–1809.
10. Ginsburg C, Griffiths PL, Richter LM, Norris SA. Residential mobility, socioeconomic context and body mass index in a cohort of urban South African adolescents. *Health Place.* 2013; 19: 99-107.
11. Flint E, Cummins S, Sacker A. Associations between active commuting, body fat, and body mass index: population based, cross sectional study in the United Kingdom. *BMJ.* 2014; 349: 1-9.
12. Ainsworth B, Haskell W, Whitt M, Irwin M, Swartz A, Strath S. et al. Compendium of physical activities: an update of activity codes and MET intensities. *Med Sci Sports Exerc.* 2000; 32: S498-S516.
13. Mutrie N, Hannah MK. Some work hard while others play hard. The achievement of current recommendations for physical activity levels at work, at home, and in leisure time in the west of Scotland. *Int J Health Promot Educ.* 2004; 42: 109-117.
14. Noh JW, Kwon UD, Park J, Oh IH, Kim J. Relationship between Physical Disability and Depression by Gender: A Panel Regression Model. *PLOS ONE.* 2016; 11: e0166238.
15. Ambresin G, Chondros P, Herrman H, Gunn JM. Self-rated Health and long-term progression of depression. *Ann Fam Med.* 2014; 12: 57-65.
16. Mood C. Life - style and self-rated global health in Sweden: A prospective analysis spanning three decades. *Prev Med.* 2013; 57: 802-806.
17. Ogilvie D, Foster CE, Rothine H. Interventions to promote walking: systematic review. *BMJ.* 2007; 304: 1204-1210.
18. Min PS, Choi YS. *STATA Panel Data Analysis.* 3rd ed. Seoul: Jipip Media; 2016.
19. Pheiffer C. Is migration a risk factor for non-communicable disease? Examining the relationship between health and geographic mobility in South Africa with nationally representative panel data. Paper presented at: PAA 2018 Annual Meeting. 2018 April 26-28; Denver, USA.
20. Reber KC, König HH, Hajek A. Obesity and sickness absence: results from a longitudinal nationally representative sample from Germany. *BMJ Open.* 2018; 8: e019839.
21. Pförtner TK, Elgar FJ. Widening inequalities in self-rated health by material deprivation? A trend analysis between 2001 and 2011 in Germany. *J Epidemiol Community Health.* 2016; 70: 82-89.
22. Peterson MD, Mahmoudi E. Healthcare Utilization Associated with Obesity and Physical Disabilities. *Am J Prev Med.* 2015; 48: 426–435.
23. Darviri C, Artemiadis AK, Tigani X, Alexopoulos EC. Lifestyle and self-rated health: a cross-sectional study of 3,601 citizens of Athens, Greece. *BMC Public Health.* 2011; 11: 619.

24. Johansson SE, Midlöv P, Sundquist J, Sundquist K, Calling S. Longitudinal trends in good self-rated health: effects of age and birth cohort in a 25-year follow-up study in Sweden. *Int J Public Health*. 2015; 60: 363-373.
25. Park JH, Kim KW, Kim MH, Kim MD, Kim BJ, Kim SK., et al. A nationwide survey on the prevalence and risk factors of late life depression in S Korea. *J Affect Disord*. 2012; 38: 34-40.
26. Grieve E, Fenwick E, Yang HC, Lean M. The disproportionate economic burden associated with severe and complicated obesity: a systematic review. *Obesity rev*. 2013; 14: 883–894.
27. Han KM, Ko YH, Yoon HK, Han C, Ham BJ, Kim YK. Relationship of depression, chronic disease, self-rated health, and gender with health care utilization among community-living elderly. *J Affect Disord*. 2018; 241: 402-410.
28. Kahn E, Ramsey L, Brownson R, Heath G, Howze E, Powell K. et al. The effectiveness of interventions to increase physical activity: a systematic review. *Am J Prev Med*. 2002; 22: 73-106.
29. Coote A. What health services could do about climate change. *BMJ*. 2006; 332: 1343-1344.
30. Pate R, Pratt M, Blair S, Haskell W, Macera C, Bouchard C. et al. Physical activity and public health: a recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. *JAMA*. 1995; 273: 402-407.
31. Mutrie N, Hannah MK. Some work hard while others play hard. The achievement of current recommendations for physical activity levels at work, at home, and in leisure time in the west of Scotland. *Int J Health Promot Educ*. 2004; 42: 109-117.
32. Whitehead M, Petticrew M, Graham H, Macintyre S, Bambra C, Egan M. Evidence for public health policy on inequalities: 2: Assembling the evidence jigsaw. *J Epidemiol Community Health*. 2004; 58: 817-821.
33. ONS: Commuting to work, Changes to Travel to Work Areas: 2001 to 2011. London: Office for National Statistics; Available from <https://www.ons.gov.uk/>.
34. Faulkner GE, Buliung RN, Flora PK, Fusco C. Active school transport, physical activity levels and body weight of children and youth: a systematic review. *Prev Med*. 2009; 48: 3-8.
35. Audrey S, Procter S, Cooper AR. The contribution of walking to work to adult physical activity levels: a cross sectional study. *Int J Behav Nutr Phys Act*. 2014; 11: 37-45.
36. Hallal PC, Andersen LB, Bull FC, Guthold R, Haskell W, Ekelund U. Global physical activity levels: surveillance progress, pitfalls, and prospects. *Lancet*. 2012; 380: 247-257.
37. Laverty AA, Mindell JS, Webb EA, Millett C. Active travel to work and cardiovascular risk factors in the United Kingdom. *Am J Prev Med*. 2013; 45: 282-288.
38. Flint E, Webb E, Cummins S. Change in commute mode and body-mass index: prospective, longitudinal evidence from UK Biobank. *Lancet Public Health*. 2016; 1: e46–e55
39. NICE: Preventing excess weight gain. UK: national Institute for Health and Care Excellence; nice guideline. Available from: [nice.org.uk/](https://www.nice.org.uk/).
40. Sacker A, Worts D, McDonough P. Social influences on trajectories of self-rated health: evidence from Britain, Germany, Denmark and the USA. *J Epidemiol Community Health*. 2011; 65: 130-136.
41. Hoebel J, Kuntz B, Kroll LE, Finger JD, Zeiher J, Lange C. Trends in absolute and relative educational inequalities in adult smoking since the early 2000s: the case of Germany. *Nicotine Tob Res*. 2018; 20: 295-302.

Tables

Table 1. General characteristics of the subjects.

	Total			Male			Female		
	M±SD n (%)	Between SD or %	Within SD or %	M±SD n(%)	Between SD or %	Within SD or %	M±SD n(%)	Between SD or %	Within SD or %
SRH	70.52±15.67	11.23	10.92	72.12±15.05	10.71	10.57	69.39±15.99	11.45	11.16
BMI	23.19±3.06	2.97	0.77	23.59±2.85	2.76	0.73	22.92±3.18	3.08	0.80
Walking	143.18±142.43	96.79	104.49	147.39±147.89	101.53	107.56	140.22±138.40	93.24	102.29
Age	52.87±15.45	15.41	1.13	53.33±15.07	15.03	1.12	52.54±15.71	15.67	1.13
Educational level	10.83±4.38	4.38	0.26	11.83±3.87	3.86	0.24	10.13±4.58	4.57	0.27
Living expenses	230.00±140.51	127.51	59.04	234.82±136.73	122.86	60.04	226.62±143.00	130.57	58.34

Mdepression									
No	2,639(7.7)	21.2	36.1	802(5.7)	16.4	34.6	1,837(9.1)	24.6	36.9
Yes	31,797(92.3)	99.4	92.9	13,390(94.4)	99.6	94.7	18,407(90.9)	99.2	91.7

Marital status									
Unmarried	3,364(9.8)	10.5	92.7	1,643(11.6)	12.3	94.0	1,721(8.5)	9.3	91.5
Married	26,464(76.8)	78.4	98.0	1,787(83.1)	84.1	98.8	14,677(72.5)	74.4	97.4
Others	4,608(13.4)	14.3	93.4	762(5.4)	5.8	92.0	3,846(19.0)	20.3	93.7

Housing type									
Owned	24,563(71.3)	78.4	90.9	10,381(73.2)	80.1	91.4	14,182(70.1)	77.3	90.6
Rent(long)	4,590(13.3)	20.0	66.6	1,798(12.7)	19.2	66.1	2,792(13.8)	20.6	66.9
Rent(short)	3,100(9.0)	12.7	71.1	1,226(8.6)	12.3	70.1	1,874(9.3)	12.9	71.8
Others	2,183(6.3)	10.7	59.1	787(5.6)	9.4	59.3	1,396(6.9)	11.7	59.1

Economic activity									
Yes	20,949(60.8)	72.2	84.3	10,944(77.1)	84.8	90.9	10,005(49.4)	63.3	78.1
No	13,487(39.2)	51.3	76.3	3248(22.9)	32.2	71.2	10,239(50.6)	64.8	78.1

Table 2. Pooled ordinary least squares (OLS) regression of self-rated health (SRH) in 2010-2013.

	Total		Male		Female	
	Coef. (95% CI)	t (p value)	Coef. (95% CI)	t (p value)	Coef. (95% CI)	t (p value)
BMI	-0.03 (-0.08~0.02)	-1.11 (.273)	0.11 (0.02~0.19)	2.42 (0.016)	-0.10 (-0.17~-0.02)	-2.63 (0.009)
Walking	0.01 (0.01~0.01)	18.11 (<.001)	0.01 (0.01~0.01)	12.10 (<.001)	0.01 (0.01~0.01)	13.78 (<.001)
Mdepression (Reference: No)	11.11 (10.43~11.80)	31.75 (<.001)	12.05 (10.85~13.25)	23.01 (<.001)	10.56 (9.73~11.39)	24.85 (<.001)
Sex (Reference: Male)	-1.30 (-1.66~-0.95)	-7.18 (<.001)				
Age	-0.14 (-0.16~-0.13)	-17.27 (<.001)	-0.10 (-0.12~-0.07)	-7.96 (<.001)	-0.16 (-0.19~-0.14)	-13.96 (<.001)
Marital status (Reference: Unmarried)						
Married	1.00 (0.41~1.59)	3.31 (.001)	-1.22 (-2.14~-0.33)	-2.61 (.009)	2.58 (1.76~3.41)	6.15 (<.001)
Others	1.08 (0.24~1.92)	2.52 (.012)	-2.54 (-4.03~-1.04)	-3.62 (<.001)	3.45 (2.35~4.54)	6.17 (<.001)
Educational level	0.44 (0.38~0.49)	15.97 (<.001)	0.36 (0.28~0.44)	9.10 (<.001)	0.50 (0.42~0.57)	13.08 (<.001)
Housing type (Reference: Owned)						
Rent(long)	-0.96 (-1.42~-0.50)	-4.06 (<.001)	-1.62 (-2.33~-0.91)	-4.50 (<.001)	-0.51 (-1.12~0.10)	-1.64 (.101)
Rent(short)	-1.42 (-2.00~-0.84)	-4.81 (0.000)	-1.16 (-2.04~-0.28)	-2.58 (.008)	-1.51 (-2.27~-0.75)	-3.88 (<.001)
Others	-0.63 (-1.30~0.05)	-1.82 (.068)	-0.60 (-1.67~0.47)	-1.10 (.260)	-0.59 (-1.46~0.28)	-1.33 (.182)
Living expenses	0.00 (0.01~0.01)	7.05 (<.001)	0.01 (0.00~0.01)	5.35 (<.001)	0.00 (0.00~0.01)	4.77 (<.001)
Economic activity (Reference: No)	-1.20 (-1.55~-0.84)	-6.63 (<.001)	-2.24 (-2.93~-1.56)	-6.89 (<.001)	-0.95 (-1.36~-0.53)	-4.45 (<.001)
Constant	63.16 (61.10-65.22)	60.07 (<.001)	58.56 (55.68-61.44)	39.83 (<.001)	61.32 (58.88-63.76)	49.32 (<.001)
	R ² =0.13	F=319.39	R ² =0.10	F=101.25	R ² =0.14	F=231.85

Table 3. Fixed-effects (FE) regression of self-rated health (SRH) in 2010-2013.

	Total		Male		Female	
	Coef. (95% CI)	t (<i>p</i> value)	Coef. (95% CI)	t (<i>p</i> value)	Coef.(95% CI)	t (<i>p</i> value)
BMI	0.14 (-0.05~0.32)	1.45 (.147)	0.10 (-0.21~0.40)	0.64 (.525)	0.16 (-0.08~0.40)	1.34 (.181)
Walking	0.01(0.00~0.01)	8.19 (<.001)	0.01 (0.00~0.01)	6.11 (<.001)	0.00 (0.00~0.01)	5.54 (<.001)
Mdepression (Reference: No)	5.61 (4.86~6.35)	14.68 (<.001)	6.17 (4.88~7.47)	9.31 (<.001)	5.35 (4.43~6.27)	11.45 (<.001)
Age	-0.93 (-1.05~-0.81)	-14.61 (<.001)	-0.99 (-1.18~-0.80)	-10.18 (<.001)	-0.89 (-1.06~-0.73)	-10.56 (<.001)
Marital status (Reference: Unmarried)						
Married	-1.55 (-3.71~1.03)	-1.11 (.267)	-2.56 (-6.25~1.13)	-1.36 (.174)	-0.75 (-3.84~2.33)	-0.48 (.632)
Others	-1.39 (-5.08~1.47)	-1.08 (.280)	-6.95 (-12.72~-1.19)	-2.36 (.018)	-0.16 (-4.17~3.85)	-0.08 (.936)
Educational level	-0.01 (-0.55~0.53)	-0.02 (.980)	-0.43 (-1.54~0.67)	-0.77 (.440)	0.25 (-0.33~0.83)	0.84 (.401)
Housing type (Reference: owned)						
Rent(long)	-0.60 (-1.53~0.32)	-1.28 (.202)	-0.91 (-2.38~0.56)	-1.21 (.225)	-0.35 (-1.55~0.84)	-0.58 (.560)
Rent(short)	0.37 (-0.89~1.61)	0.56 (.577)	-0.94 (-2.83~0.95)	-0.98 (.329)	1.27 (-0.38~2.92)	1.51 (.132)
Others	0.02 (-1.16~1.21)	0.04 (.966)	1.10 (-0.78~2.97)	1.15 (.251)	-0.57 (-2.10~0.96)	-0.73 (.464)
Living expenses	0.00 (-0.00~0.00)	1.94 (.052)	0.00 (0.00~0.00)	0.57 (.572)	0.00 (0.00~0.01)	2.12 (.034)
Economic activity (Reference: No)	0.02 (-0.63~0.63)	0.01 (.993)	0.17 (-0.98~1.33)	0.29 (.770)	-0.06 (-0.81~0.69)	-0.15 (.879)
Constant	111.99 (101.38~120.64)	22.60 (<.001)	123.15 (105.62~140.68)	13.76 (<.001)	104.25 (92.73~115.76)	17.50 (<.001)
Rho		0.62		0.58		0.58