Title Page

Prospective association between late-life physical activity and hospital care utilisation: A seven-year nationwide follow-up study

Po-Wen Ku, Andrew Steptoe, Yi-Huei Chen, Li-Jung Chen*, Ching-Heng Lin*

Submission to *Age and Ageing*

1st author: Po-Wen Ku, PhD (Epidemiology) and PhD (Exercise and Health)
Graduate Institute of Sports and Health, National Changhua University of Education, Taiwan
Department of Epidemiology and Public Health, University College London, UK

2nd author: Andrew Steptoe, DPhil, DSc
Department of Epidemiology and Public Health, University College London, UK

3rd author: Yi-Huei Chen, MSc
Department of Medical Research, Taichung Veterans General Hospital, Taichung, Taiwan

4th and corresponding author: Li-Jung Chen*, PhD
Department of Exercise Health Science, National Taiwan University of Sport, Taichung, Taiwan
Department of Epidemiology and Public Health, University College London, London, UK
Address: No. 271, Lixing Road, Taichung City, Taiwan 404
E-mail: ljchen@ntupes.edu.tw; Telephone: +886 (4) 2221-3135 ext.1310

5th author and co-corresponding author: Ching-Heng Lin*, PhD
Department of Medical Research, Taichung Veterans General Hospital, Taichung, Taiwan
Address: 1650 Taiwan Boulevard Sect. 4, Taichung, Taiwan 40705
E-mail: joelin99@gmail.com; Telephone: +886 (4) 2359-2525 ext.4089

* Corresponding author

Word count for text: 2,497; abstract: 242

Abstract

Background: It is still equivocal whether there is a potential role of late-life physical activity in ameliorating the challenges of increasing health care expenditure due to the consequence of global population ageing.

Objective: This study aimed to examine the prospective association between physical activity and subsequent hospital care utilisation in older adults, and to explore the optimal dose of physical activity required to reduce hospital care utilisation.

Design: This was a prospective cohort study based on the data from the Taiwan 2005 National Health Interview Survey, which were linked to the 2005-2012 claims data from the National Health Insurance system.

Participants: 1,760 older adults aged 65 or more.

Methods: The frequency, duration and intensity for physical activity were assessed and total physical activity energy expenditure was estimated. The average annualized hospital care utilisation for the period 2006 through 2012, including number of hospitalisations, number of days in hospital, and the costs of hospitalisation, were calculated.

Results: Older adults engaging in at least moderate volume of physical activity (1000+ kcal/week) experienced fewer subsequent hospital admissions and fewer days in hospital than did sedentary individuals, after adjusting for covariates. Trends for reduced hospitalisation costs were also found. These associations persisted in sensitivity analyses, including tests of reverse causation.

Conclusion: This study has provided evidence that older adults who are at least moderately active may minimize utilisation of hospital care services. The findings highlight the importance of maintaining a physically active lifestyle in later life.

Keywords: Exercise, health service, lifestyle, hospitalisation, older adult

Introduction

There is well-documented evidence for the benefits of physical activity for a range of health conditions [1, 2], and these positive health consequences continue into older ages [3]. The rapidly increasing proportion of people aged 65 or older in many countries around the world has stimulated growing concern over the impact on health care systems. Increasing attention is being paid by health service providers and policy makers to the potential role of physical activity in ameliorating these challenges [4].

Although previous studies have shown that greater physical activity is associated lower health service utilisation, few have focused on older populations [5-7]. Prospective studies examining the relationship have suffered from methodological limitations such as short follow-up periods [8, 9], failure to adjust for health care utilisation at baseline [10-12], self-reported health care use [11], and small sample sizes [9, 12]. Besides, the previous studies of this topic have been mainly conducted in North America and European countries. There are considerable socio-economic, political and cultural differences between East Asian and Western countries that may influence health care services and physical activity patterns. To date, there is a paucity of published data on the relationships between physical activity and health care utilization among older adults in East Asia.

We took advantage of the comprehensive hospital care records in Taiwan to address some of these shortfalls by exploring the prospective associations between physical activity and subsequent health service utilisation (including hospital admissions, hospitalisation days and related costs) in a seven-year follow-up (2005-2012) of a nationally representative sample of older adults. We adjusted for multiple potentially confounding factors, and carried out sensitivity analyses to test for reverse causality. Public health recommendations call for 30 minutes or more of at least moderate-intensity physical activity on most days of the week (approximately 1000+ kcal/week) [13, 14]. However, few data are available regarding the optimal volume of physical activity required to influence health care use. Our second aim was therefore to identify the amount of physical activity needed to reduce hospital care utilisation.

Methods

Study design and sample

This was a prospective study involving participants aged 65 and older in the 2005 National Health Interview Survey (NHIS) in Taiwan, which was conducted by the National Health Research Institutes and Bureau of Health Promotion, Taiwan. The NHIS comprised 24,726 participants (response rate =80.59%) with 2,727 being aged 65 or older. Participants were selected using multistage stratified systematic sampling design to select a nationally representative sample [15].

The NHIS data were linked to the 2005-2012 claims data in the National Health Insurance Research Database. National Health Insurance in Taiwan is a public compulsory insurance system for all citizens (coverage rate = 99.6% of the total population 23.1 millions in 2009) [16]. Among 2727 older adults, 1760 (65%) provided the consent to link their claim data.

Ethics statement

Ethics approval for this study was obtained from Taichung Veterans General Hospital Institutional Review Board, Taiwan (reference number: SE14257A-1).

Measures

Outcome variables: Hospital care utilisation

Based on the claim data from the Taiwan National Health Insurance Database, the average annualized hospital care utilisation for the period 2006 through 2012, including number of hospitalisations, number of days in hospital, and the costs of hospitalisation (US dollars), were calculated.

Exposure variable: Physical activity

Two types of physical activity were measured in the 2005 NHIS. Leisure-time physical activity was assessed using the following questions. ‘Have you taken part in any leisure-time physical activities in the past 2 weeks?’ Respondents were asked to identify the types of leisure-time physical activity they had engaged in from 31 named activities (e.g. walking, swimming, Tai Chi etc.), and were able to specify up to five types. Participants self-reported the frequency and duration for each activity. Metabolic equivalent (MET) intensity levels for each activity were assigned based on the compendium of physical activities [17]. Energy expenditure (kcal) of each activity per week was calculated by: activity intensity code (kcal/min) × frequency per week (times) × duration for each time (min). The energy expenditure values were then added to provide a total weekly sum for leisure-time activity. Participation in heavy physical labour during non-leisure time was assessed with the item, 'Have you taken part in any heavy physical labour in the past 2 weeks?' Respondents were then requested to identify the type of activity they engaged in from 10 types of activities (e.g. farm work, heavy lifting, fishing work, heavy household chores) and could specify up to five types. The total weekly amount of energy expenditure for heavy physical labour was then estimated as before. The sum of weekly total physical activity was computed to estimate total weekly energy expenditure, which was classified into four categories (no physical activity= 0, low levels= 1-999, moderate levels= 1000-1999, and high levels= 2000+ kcal/week) [14]. These measures have been employed in previous research [18, 19], with repeated measurements (n= 72) at 1, 3, and 6 months post-interview. Consistency of the main question (i.e. whether engaging in physical activity in the past two weeks) was 0.88, while Kappa scores for repeated measures of frequency and duration ranged between 0.41 and 0.46, providing acceptable reliability of the items utilised by the study [19, 20]. The content validity of all of the items in National Health Interview Survey was reviewed by expert panels, and the whole questionnaire was then administered twice in pilot testing [21]. The physical activity questionnaires were used in the 2001, 2005, 2009, 2013 National Health Interview Surveys, and functioned well. Additionally, participants with a higher level of total physical activity (esp. more than 1000 kcal/week) in this study had lower rates of overweight/obesity impaired activities of daily living (ADL), and multiple comorbidity (all *p*-values for chi-square tests < 0.001). This provides further evidence for the validity of this instrument.

Covariates

The following potentially relevant factors in 2005 NHIS were included as covariates based on previous studies [5, 15]: (i) socio-demographic factors: sex, age (65-74, 75-84, 85+), education level (no formal schooling and primary school+), marital status (married/cohabitating, others), working status (retired/unable to work, homemaker, and currently employed), monthly income (US dollar) (< 330, 330-659, 660+), and living status (alone vs. with family/others); (ii) lifestyle behaviours: alcohol consumption (yes vs. no), and smoking (current smoker, former smoker, and never smoked); (iii) health status: body mass index (BMI) (<18.50, 18.50-23.99, 24-26.99, 27+) [22], Charlson comorbidity index (0, 1-2, ≧3), which considers the number and severity of chronic diseases [23, 24], and impaired ADL (no difficulties at all vs. some or great difficulties); and (iv) hospital care utilisation at baseline.

Data analysis

Descriptive statistics for each aspect of hospital care utilisation were calculated first to characterize the sample structure. Given the violation of normality, Mann-Whitney U test and Kruskal-Wallis test were used to test for differences across levels of physical activity and covariates. Variables with a *p* value < 0.05 were included in the following regression models for adjustment.

Given that the distribution of hospital care utilisation variables was positively skewed and over-dispersed, Poisson regression, negative binomial regression, zero-inflated negative binomial regression, and linear regression with a log transformed response were considered for analysing the data [25-27]. The model selections were based on the Akiake Information Criterion (AIC). The prospective associations between physical activity and hospital care services were examined using Poisson regression for number of hospitalisations, negative binomial regression for number of hospitalisation days, and linear regression with a log transformed response for hospitalisation costs respectively (model 1).

To assess the dose-response associations between physical activity and hospital care utilisation, we tested for linear trends across activity categories. To examine the potential influence of individuals with extreme consumption of health care resources (outliers: more than 3 standard deviations from the mean) [28] at baseline and the follow-up, participants who had extreme hospitalisation costs in 2005 or during the follow-up period (2006-2012) were excluded (n=32) (Model 2). Given that the inclusion of participants with very poor health, difficulties in physical function or limited pulmonary function might affect the estimate of physical activity-hospital care utilisation relationships, several sensitivity analyses were performed to address reverse causation, First, participants who died during the first two years of follow-up (2005-2007, n=181) were excluded (model 3). Then, participants who had any condition including difficulty with ADL, arthritis, and chronic obstructive pulmonary diseases (COPD) (n=475) at baseline were excluded (model 4).

All analyses were conducted using SAS 9.4 software and a *p* value < 0.05 was considered statistically significant.

Results

The associations between baseline characteristics and annual mean number of hospitalisations, number of days in hospital, and hospital care costs are summarized in Table 1. All independent variables, with the exception of sex, educational level, monthly income, and living status, were significantly associated with hospital care utilisation variables ($p< 0.05$). Participants who were younger, married/cohabiting, currently working, with a higher level of physical activity, consumers of alcohol and who never smoked, and were overweight, had no comorbidities and less difficulty with activities of daily living, had lower hospital care utilisation over the follow-up period. Additionally, older women had lower numbers of hospital admission, while participants who were better educated had fewer hospital admissions and hospitalisation days but no differences in costs.

Table 1

The overall prevalence of engaging in physical activity at moderate or higher levels (i.e. 1000+ kcal/week) was 37.9% (see Table 2). Participants with the moderate or high levels of activity were more likely to be male, younger, better educated, married/cohabitating, currently working, with higher income, currently drinking and smoking, overweight, and had less comorbidity and no difficulties in ADL.

Table 2

The results of the fully adjusted multivariable regression models (Model 1 in Table 3) show that those who engaged in moderate or higher levels of physical activity had a significantly lower number of hospital admissions and fewer days in hospital, than those who were not active. Differences were substantial, with an approximate 30% reduction in number of hospital admissions and number of days in hospital among more active participants. It seemed that older adults with high levels of physical activity (i.e. 2000+ kcal/week) did not show a further large reduction in hospital care utilisation in comparison with those with moderate levels of physical activity (i.e. 1000-1999 kcal/week). Although the tests for linear trend supported an inverse dose-response relationship between physical activity energy expenditure and hospital care costs, it appeared that only individuals with high levels of physical activity had a significant but small reduction of expenditure (approximately 10%). A similar pattern was also observed in the sensitivity analyses (model 2-4) although effects for moderate physical activity were not significant in model 4, probably because of the smaller sample size.

Table 3

Discussion

This population-based seven-year follow-up study revealed that older adults engaging in regular physical activity, especially at moderate or higher levels (1000+ kcal/week), have less utilisation of hospital care services, including hospital admissions and hospitalisation days over subsequent years. Trends for reduced hospitalisation costs were also found but this association was only identified in those reporting high levels of physical activity (2000+ kcal/week). These results were observed in multivariable regression models after adjusting for the baseline outcome measurements, socio-demographic variables, lifestyle behaviours, and comorbid conditions. Sensitivity analyses for assessing reverse causation provided further support to the robustness of these findings.

This study demonstrates that late-life physical activity is associated with lower utilisation of subsequent hospital care services, supporting the previous findings of prospective studies based on community-dwelling older adults [11, 12]. The protective effect of physical activity on subsequent hospital care utilisation in this study, though substantial, is smaller than that described in previous studies [10-12]. This may be due to the more comprehensive covariates (such as baseline hospital care utilisation) included in the present study. In contrast, the results of previous studies were estimated without controlling for the baseline status of hospital care utilisation, which may lead to the overestimation of the strength of associations. Differences in the prospective associations of physical activity with hospital care utilisation may also be due to methodological variations in quantifying and reporting physical activity and the heterogeneity of samples.

This study indicated that older adults who are at least moderately active (the equivalent of walking for roughly 30 minutes or more per day) [29] had lower utilisation of subsequent hospital care services such as hospital admission and hospitalisation days. Notably, more intense physical activity (i.e. expending 2000+ kcal/week) did not yield a further large reduction in hospital care utilisation in comparison with moderate levels of physical activity (i.e.. 1000-1999 kcal/week). This echoes the recommendations for the public that call for 30 minutes or more of at least moderate-intensity physical activity on most days of the week [3]. These findings were further confirmed using sensitivity analyses in model 2-4, and were not due to the inclusion of very high hospital care users (model 2).

The trend across physical activity categories and hospital care costs was significant in this study, but the significant and small effect on cost reduction (approximate 10%) was only found in the group reporting high physical activity. The association remained significant even when participants who had extreme hospitalisation costs were excluded. It is possible that the determinants of hospital care spending are different from those of hospital admission and hospitalisation days. Costs not only relate to the severity of the condition but patients' treatment preferences and physicians' beliefs and financial incentives [30]. These underlying factors may attenuate the relationship of physical activity with hospitalisation costs.

Although this prospective study was conducted adjusting for a comprehensive range of potential confounders based on a nationally representative sample, it inevitably has some limitations. First, the assessment of physical activity, including leisure time, household and work-related physical activity, were self-reported, so may have been susceptible to recall bias, especially in aging populations. Physical activity was assessed using a single measurement, but levels may change over time. Finally, although the hospital care data were based on the compulsory national health insurance program for all citizens, 35% of participants in 2005 Taiwan NHIS did not provide the consent to link their claim data. There were no significant differences between individuals who did and did not consent in terms of age at baseline. However, those who did not consent to link the claim data were more likely to be female, have lower education attainment, be physically inactive, and experience more chronic conditions and difficulties with ADL (all *p*-values for chi-square tests < 0.05, data not shown). Because physical inactivity and hospital care utilisation are likely to be more common in this sector of the population, any selection bias may have led to underestimation of the association between physical activity and hospital care utilisation. This is an observational study, which cannot establish causality. A well-designed large-scale randomized controlled trial with a representative sample would be needed to verify these findings.

This study has provided evidence that older adults who are at least moderately active may reduce utilisation of hospital care services. The findings highlight the importance of maintaining a physically active lifestyle in later life.

Acknowledgement

The authors would like to thank The Health and Welfare Data Science Centre, Ministry of Health and Welfare (HWDC, MOHW) for support and the Healthcare Service Research Centre (HSRC) of Taichung Veterans General Hospital for statistical support.

Funding: This study was supported by grants from the Taiwan Ministry of Science and Technology (NSC 101-2314-B-075A-008; MOST 103-2314-B-075A-006).

Conflict of interest disclosures: None were reported.

References

1. World Health Organization. Global health risks: mortality and burden of disease attributable to selected major risks. Geneva: World Health Organization; 2009.
2. Lee I-M, Shiroma EJ, Lobelo F, Puska P, Blair SN, Katzmarzyk PT*, et al.* Effect of physical inactivity on major non-communicable diseases worldwide: An analysis of burden of disease and life expectancy. The Lancet. 2012;380(9838):219-29.
3. World Health Organization. Global recommendations on physical activity for health. Geneva: World Health Organization,; 2010.
4. Kohl HW, Craig CL, Lambert EV, Inoue S, Alkandari JR, Leetongin G*, et al.* The pandemic of physical inactivity: Global action for public health. The Lancet. 2012;380(9838):294-305.
5. Sari N. Exercise, physical activity and healthcare utilization: A review of literature for older adults. Maturitas. 2011;70(3):285-9.
6. Pratt M, Norris J, Lobelo F, Roux L, Wang G. The cost of physical inactivity: moving into the 21st century. Brit J Sport Med. 2014;48(3):171-3.
7. Katzmarzyk PT, Gledhill N, Shephard RJ. The economic burden of physical inactivity in Canada. CMAJ. 2000;163(11):1435-40.
8. Perkins AJ, Clark DO. Assessing the association of walking with health services use and costs among socioeconomically disadvantaged older adults. Prev Med. 2001;32(6):492-501.

9. Esteban C, Arostegui I, Aburto M, Moraza J, Quintana JM, Aizpiri S, *et al.* Influence of changes in physical activity on frequency of hospitalization in chronic obstructive pulmonary disease. Respirology. 2014;19(3):330-8.

10. Li C-L, Chu S-J, Sheu J-T, Huang LY-G. Impact of physical activity on hospitalization in older adults: A nationwide cohort from Taiwan. Arch Gerontol Geriatr. 2011;53:141-5.

11. Jacobs JM, Rottenberg Y, Cohen A, Stessman J. Physical activity and health service utilization among older people. J Am Med Dir Assoc. 2013;14(2):125-9.

12. Simmonds B, Fox KR, Davis M, Ku PW, Gray S, Hillsdon M, *et al.* Objectively assessed physical activity and subsequent health service use of UK adults aged 70 and over: A four to five year follow up study. PloS one. 2014;9(5):e97676.

13. Blair SN, LaMonte MJ, Nichaman MZ. The evolution of physical activity recommendations: How much is enough? Am J Clin Nutr. 2004, 2004;79(5):913S-20S.

14. Lee I-M, Skerrett PJ. Physical activity and all-cause mortality: What is the dose-response relation? Med Sci Sports Exerc. 2001;33(6 Suppl.):S459-S71.

15. Pu C, Bai YM, Chou YJ. The impact of self-rated health on medical care utilization for older people with depressive symptoms. Int J Geriatr Psychiatry. 2013;28(5):479-86.

16. Jiang Y-D, Chang C-H, Tai T-Y, Chen J-F, Chuang L-M. Incidence and prevalence rates of diabetes mellitus in Taiwan: Analysis of the 2000–2009 Nationwide Health Insurance database. J Formos

Med Assoc. 2012;111(11):599-604.

17. 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(9):S498-S516.

18. Chen LJ, Stevinson C, Ku PW, Chang YK, Chu DC. Relationships of leisure-time and non-leisure-time physical activity with depressive symptoms: A population-based study of Taiwanese older adults. Int J Behav Nutr Phys Act. 2012;9(28):1-10.

19. Lan T-Y, Chang H-Y, Tai T-Y. Relationship between components of leisure physical activity and mortality in Taiwanese older adults. Prev Med. 2006;43(1):36-41.

20. Pan WH, Hung YT, Shaw NS, Lin W, Lee SD, Chiu CF, *et al.* Elderly Nutrition and Health Survey in Taiwan (1999-2000): research design, methodology and content. Asia Pac J Clin Nutr. 2005;14(3):203-10.

21. Shih YT, Hung YT, Chang HY, Liu JP, Lin HS, Chang MC, *et al.* The design, contents, operation and the characteristics of the respondents of the 2001 National Health Interview Survey in Taiwan. Taiwan Journal of Public Health. 2003;22(6):419-30.

22. Taiwan Department of Health. Identification, evaluation, and treatment of overweight and obesity in adults in Taiwan. Taipei: Taiwan Department of Health; 2003.

23. Quan H, Sundararajan V, Halfon P, Fong A, Burnand B, Luthi J-C, *et al.* Coding algorithms for

defining comorbidities in ICD-9-CM and ICD-10 administrative data. Med Care. 2005:1130-9.

24. Deyo RA, Cherkin DC, Ciol MA. Adapting a clinical comorbidity index for use with ICD-9-CM administrative databases. J Clin Epidemiol. 1992;45(6):613-9.

25. Elhai JD, Calhoun PS, Ford JD. Statistical procedures for analyzing mental health services data. Psychiatry Res. 2008;160(2):129-36.

26. Sari N. A short walk a day shortens the hospital stay: physical activity and the demand for hospital services for older adults. Can J Public Health. 2010;101(5):385-9.

27. Sari N. Sports, eercise, and length of stay in hospitals: Is there a differential effect for the chronically ill people? Contemp Econ Policy. 2014;32(2):247-60.

28. Baandrup L, Sørensen J, Lublin H, Nordentoft M, Glenthoj B. Association of antipsychotic polypharmacy with health service cost: A register-based cost analysis. Eur J Health Econ. 2012;13(3):355-63.

29. Kokkinos P, Myers J. Exercise and Physical Activity: Clinical Outcomes and Applications. Circulation. 2010;122(16):1637-48.

30. Oshima Lee E, Emanuel EJ. Shared Decision Making to Improve Care and Reduce Costs. N Engl J Med. 2013;368(1):6-8.

Table 1 Characteristics of participants aged 65 or older with hospital care utilisation during the period 2006-2012 in Taiwan

Variables in 2005	n	Annual mean number of hospitalisation		*P*-value[a]	Annual mean number of hospitalisation days		*P*-value[a]	Annual mean of hospitalisation costs (USD)		*P*-value[a]
		Mean	SD		Mean	SD		Mean	SD	
Socio-demographic										
Sex				0.026			0.063			0.074
Female	824	0.4	0.7		6.6	23.6		1237.3	3433.6	
Male	936	0.5	0.6		6.4	20.0		1337.4	3524.6	
Age				<0.001			<0.001			<0.001
85+	97	0.7	0.7		14.3	38.4		2456.9	6227.2	
75-84	595	0.5	0.6		8.1	20.3		1562.7	3317.4	
65-74	1068	0.4	0.6		5.0	20.2		1033.0	3183.8	
Education level				0.007			0.011			0.062
No formal schooling	613	0.5	0.7		8.1	26.1		1466.1	3699.0	
Primary school+	1144	0.4	0.6		5.6	18.9		1192.3	3359.0	
Marital status				<0.001			<0.001			0.001
Others	602	0.5	0.7		8.6	27.8		1586.8	4149.6	
Married/cohabiting	1158	0.4	0.6		5.5	17.7		1136.5	3068.4	
Working status				<0.001			<0.001			<0.001
Retired/unable to work	1154	0.5	0.7		7.3	22.6		1425.1	3441.2	
Housekeeper	305	0.4	0.6		6.6	25.0		1222.3	3757.2	
Currently working	276	0.3	0.5		3.0	12.0		637.6	2023.7	
Monthly income (USD)				0.217			0.255			0.375
<330	1189	0.4	0.7		6.5	20.0		1326.4	3444.6	
330-659	280	0.5	0.7		7.8	29.7		1322.2	3513.9	

660+	281	0.3	0.5		5.5	19.6		1112.5	3656.1	
Living status				0.672			0.695			0.592
Alone	176	0.4	0.6		5.4	13.3		1024.9	2278.1	
With family/others	1584	0.4	0.7		6.7	22.5		1320.0	3589.9	
Lifestyle behaviours										
Physical activity (kcal/wk)				<0.001			<0.001			<0.001
None (0)	605	0.6	0.8		10.7	30.8		1933.3	4632.8	
Low (1-999)	488	0.4	0.6		6.6	20.8		1355.4	3576.6	
Moderate (1000-1999)	262	0.3	0.5		3.3	6.9		830.5	1906.9	
High (2000+)	405	0.3	0.5		2.4	5.5		549.8	1268.7	
Drinking				0.006			0.008			0.009
Yes	365	0.3	0.5		3.4	6.9		739.8	1426.5	
No	1395	0.5	0.7		7.3	24.1		1434.6	3829.5	
Smoking				0.002			0.001			0.002
Current smoker	311	0.5	0.8		5.8	10.7		1242.2	2440.9	
Former smoker	204	0.6	0.8		10.2	33.0		2005.1	6137.5	
Never smoked	1203	0.4	0.6		6.0	21.5		1180.2	3382.4	
Health Status										
Body mass index				0.003			0.002			0.013
Underweight <18.5	105	0.7	0.8		12.3	32.7		2231.6	5204.0	
Obese 27+	327	0.4	0.7		6.5	25.4		1167.3	2991.6	
Overweight 24-26.99	468	0.4	0.6		4.4	10.0		1052.7	2828.1	
Normal 18.5-23.99	804	0.4	0.6		5.8	16.6		1202.6	3077.8	
Charlson comorbidity index				<0.001			<0.001			<0.001
≧ 3	336	0.7	0.9		10.6	29.7		1895.5	3989.3	
1-2	708	0.5	0.6		8.0	25.3		1585.9	4291.6	

0	716	0.3	0.5		3.2	9.6		714.6	1887.5	
Activities of daily living				<0.001			<0.001			<0.001
With difficulty	236	0.8	0.8		19.9	46.1		3576.5	7264.6	
No difficulties at all	1524	0.4	0.6		4.5	13.6		936.5	2218.5	

USD= United States Dollar; United States Dollar to Taiwanese Dollar exchange rate= 1: 30

a: test for Mann-Whitney U test or Kruskal-Wallis test

Table 2 Characteristics of participants aged 65 or older at baseline by overall physical activity

Variables in 2005	Total	Overall physical activity								*P* for
	N	None		Low		Moderate		High		chi-square
		N	%	N	%	N	%	N	%	test
Socio-demographic										
Sex										<0.001
Female	824	326	(39.6)	245	(29.7)	111	(13.5)	142	(17.2)	
Male (>=1000)	936	279	(29.8)	243	(26.0)	151	(16.1)	263	(28.1)	
Age										<0.001
85+	97	58	(59.8)	19	(19.6)	8	(8.2)	12	(12.4)	
75-84	595	247	(41.5)	171	(28.7)	79	(13.3)	98	(16.5)	
65-74	1068	300	(28.1)	298	(27.9)	175	(16.4)	295	(27.6)	
Education level										<0.001
No formal schooling	613	275	(44.9)	162	(26.4)	72	(11.7)	104	(17.0)	
Primary school+	1144	328	(28.7)	325	(28.4)	190	(16.7)	301	(26.3)	
Marital status										<0.001
Others	602	252	(41.9)	177	(29.4)	83	(13.8)	90	(15.0)	
Married/cohabiting	1158	353	(30.5)	311	(26.9)	179	(15.5)	315	(27.2)	
Working status (H1, H1A)										<0.001
Retired/unable to work	1154	402	(34.8)	329	(28.5)	191	(16.6)	232	(20.1)	
Housekeeper	305	140	(45.9)	94	(30.8)	36	(11.8)	35	(11.5)	
Currently working	276	57	(20.7)	57	(20.7)	33	(12.0)	129	(46.7)	
Monthly income (NT dollar)										<0.001
0-9999	1189	460	(38.7)	324	(27.2)	155	(13.0)	250	(21.0)	
10000-19999	280	81	(28.9)	86	(30.7)	46	(16.4)	67	(23.9)	
20000+	281	60	(21.4)	77	(27.4)	58	(20.6)	86	(30.6)	

Living status										0.507
Alone	176	55	(31.3)	45	(25.6)	30	(17.0)	46	(26.1)	
With family/others	1584	550	(34.7)	443	(28.0)	232	(14.6)	359	(22.7)	
Lifestyle behaviours										
Drinking										<0.001
Yes	365	93	(25.5)	83	(22.7)	64	(17.5)	125	(34.2)	
No	1395	512	(37.6)	405	(29.0)	198	(14.2)	280	(20.1)	
Smoking										0.027
Current smoker	311	102	(32.8)	76	(24.4)	48	(15.4)	85	(27.3)	
Former smoker	204	69	(33.8)	50	(24.5)	24	(11.8)	61	(29.9)	
Never smoked	1203	418	(34.7)	350	(29.1)	186	(15.5)	249	(20.7)	
Health Status										
Body mass index										<0.001
Underweight <18.5	105	59	(56.1)	20	(19.0)	9	(8.6)	17	(16.2)	
Obese 27+	327	108	(33.0)	92	(28.1)	62	(19.0)	65	(19.9)	
Overweight 24-26.99	468	130	(27.8)	136	(29.1)	89	(19.0)	113	(24.1)	
Normal 18.5-23.99	804	272	(33.8)	227	(28.2)	98	(12.2)	207	(25.7)	
Charlson comorbidity index										<0.001
≧3	336	154	(45.8)	91	(27.1)	43	(12.8)	48	(14.3)	
1-2	708	263	(37.1)	193	(27.3)	100	(14.1)	152	(24.5)	
0	716	188	(26.3)	204	(28.5)	119	(16.6)	205	(28.6)	
Activities of daily living										<0.001
Some or great difficulties	236	183	(77.5)	41	(17.4)	9	(3.8)	3	(1.3)	
No difficulties at all	1524	422	(27.7)	447	(29.3)	253	(16.6)	402	(26.4)	

Table 3 Multivariable regression model for adjusted rate ratios (RRs) of physical activity for predicting hospital care utilisation

	Annual mean number of hospitalisation				Annual mean number of hospitalisation days				Annual mean of hospitalisation costs			
	n	RRs	95% CI	*P*-value	n	RRs	95% CI	*P*-value	n	RRs	95% CI	*P*-value
Model 1	1637				1637				1640			
PA				0.002+				0.024+				0.033+
None (ref.)		1.00	—	—		1.00	—	—		1.00	—	—
Low		0.87	(0.71-1.05)	0.145		1.09	(0.88-1.36)	0.422		1.00	(0.91-1.08)	0.908
Moderate		0.71	(0.55-0.92)	0.010		0.67	(0.51-0.87)	0.003		0.98	(0.89-1.09)	0.734
High		0.72	(0.57-0.92)	0.008		0.65	(0.50-0.83)	<0.001		0.89	(0.80-0.99)	0.033
Model 2	1605				1605				1608			
PA				0.001+				0.002+				0.047+
None (ref.)		1.00	—	—		1.00	—	—		1.00	—	—
Low		0.89	(0.73-1.09)	0.249		1.04	(0.84-1.28)	0.722		1.01	(0.92-1.10)	0.884
Moderate		0.73	(0.56-0.95)	0.018		0.74	(0.57-0.96)	0.025		0.99	(0.89-1.10)	0.816
High		0.69	(0.54-0.89)	0.004		0.70	(0.55-0.89)	0.003		0.90	(0.81-1.00)	0.053
Model 3	1464				1464				1466			
PA				0.001+				0.001+				0.024+
None (ref.)		1.00	—	—		1.00	—	—		1.00	—	—
Low		0.90	(0.73-1.12)	0.343		1.10	(0.89-1.37)	0.364		1.02	(0.93-1.11)	0.714
Moderate		0.73	(0.55-0.98)	0.033		0.74	(0.57-0.97)	0.026		0.98	(0.88-1.09)	0.734
High		0.70	(0.54-0.91)	0.009		0.70	(0.55-0.89)	0.004		0.89	(0.80-0.99)	0.031
Model 4	1203				1203				1203			

PA			0.003^{+}			0.006^{+}			0.051^{+}
None (ref.)	1.00	—	—	1.00	—	—	1.00	—	—
Low	0.84	(0.66-1.08)	0.168	1.04	(0.80-1.35)	0.773	0.97	(0.88-1.08)	0.609
Moderate	0.76	(0.56-1.03)	0.075	0.78	(0.58-1.05)	0.102	1.00	(0.88-1.12)	0.942
High	0.68	(0.51-0.90)	0.007	0.72	(0.55-0.96)	0.024	0.87	(0.78-0.98)	0.026

Model 2= Model 1 excluding those with a extremely high hospitalisation cost in 2005 and the follow-up period, 2006-12

Model 3= based on Model 2 excluding those died in 2005-2007

Model 4= based on Model 2 excluding those with ADL, arthritis, and COPD in 2005

PA= Physical activity; ADL= Activities of daily living; COPD= chronic obstructive pulmonary disease

+ = P-value for trend using linear regression with multivariable adjustment

Covariates in all models: Baseline hospital care utilisation, sex (only adjusting for annual mean number of hospitalisation), age, education level (only adjusting for annual mean number of hospitalisation and annual mean number of hospitalisation days), marital status, working status, alcohol consumption, smoking, BMI, Charlson comorbidity index, and ADL.