

Less exercise and more TV: leisure-time physical activity trends of Shanghai elders, 1998–2008

Qiushi Feng^{1†}, Jama L. Purser^{1,2†}, Zhihong Zhen³, Pamela W. Duncan^{1,2}

¹Division of Physical Therapy, Department of Community and Family Medicine, Duke University Medical Center, 2200 West Main Street, Suite B230, Durham, NC 27708, USA

²Division of Geriatrics, Department of Medicine, Duke University Medical Center, Durham, NC 27708, USA

³Department of Economic Sociology, School of Humanity, Shanghai University of Finance and Economics, 777 Guoding Road, Shanghai 200433, China

Address correspondence to Qiushi Feng, Email: qiushi.feng@duke.edu

ABSTRACT

Background Surveillance of physical activity trends in older adults is limited in developing nations. This study examined 10-year leisure-time physical activity trends of elderly residents of Shanghai, the largest Chinese city with the nation's highest proportion of senior citizens.

Methods The study used panel data from the Shanghai Longitudinal Survey of Elderly Life and Opinion (1998, 2003, 2005 and 2008). Leisure-time physical activity questions included (i) 16 major leisure-time habitual activities and (ii) regular exercise in the previous 6 months.

Results In comparison to 1998, for Shanghai elders, the trend for engaging in leisure-time habits not related to physical activity increased over time, becoming statistically significant in 2005 and 2008 (e.g. OR for watching TV in 2003, 2005 and 2008 is 1.04 [0.91, 1.19], 1.17 [1.00, 1.38] and 1.78 [1.51, 2.09], respectively). Simultaneously, the trend for engaging in regular exercise declined significantly in each observation year in comparison to 1998 (OR in 2003, 2005 and 2008 is 0.70 [0.61, 0.80], 0.36 [0.30, 0.42] and 0.28 [0.24, 0.33], respectively).

Discussion An increasingly sedentary lifestyle has evolved over the past decade in Shanghai. This highlights a need for public health agencies to develop effective active lifestyle interventions and physical activity promotion programs for local elders.

Keywords exercise, leisure-time habit, older adults, physical activity, Shanghai

Introduction

Physical activity in older adults, in particular regular physical exercise, improves functional health, including walking endurance and walking speed,^{1,2} enhances cognition³ and mental health,⁴ reduces risk and controls progression of major chronic conditions such as hypertension,⁵ cardiovascular diseases,⁶ diabetes⁷ and arthritis,⁸ and improves quality of life.⁹ Numerous clinical and public health strategies have been promoted to enhance physical activity in western countries.^{10–13} Recently, growing interest has focused on the generalization of such strategies and development of similar programs in the developing world.^{14,15} In developing countries, which host approximately two-thirds of the world's total elderly population, non-communicable diseases have become a major burden for local public health systems.¹⁶ Most of these conditions are associated with

health behaviors such as low physical activity, and lifestyle interventions are urgently needed.¹⁷

Developing nations face unique challenges in the endeavor to promote active lifestyles for seniors. For example, rapid modernization and urbanization in these countries has imported new ideas, cultures, cuisines and technologies, which often alter traditional lifestyles toward more sedentary behaviors, unhealthy eating practices and consequent increases in chronic diseases associated with such

Qiushi Feng, Postdoctoral Research Associate of Community and Family Medicine

Jama L. Purser, Assistant Professor of Community and Family Medicine

Zhihong Zhen, Associate Professor of Sociology

Pamela W. Duncan, Professor, Doctor of Physical Therapy

[†]The first two authors contributed equally to the manuscript.

lifestyles.^{18,19} Moreover, public health infrastructure for healthy aging and physical activity promotion in these countries is frequently underdeveloped. This is particularly true for China, which houses one-fourth of the world's total elderly population, is experiencing extraordinarily fast economic development and severe challenges in improving its public health system.^{20,21} Recent medical reform in China has markedly expanded national medical insurance coverage for seniors, the effect of which could be maximized if implemented in parallel with public health promotion programs to improve lifestyle behaviors such as physical activity.²² Understanding recent trends in health behaviors among Chinese older adults is thus extremely important to the development of public health and policy initiatives to promote health, function and well-being of the elderly.

The current analysis aims to examine leisure-time physical activity trends in Shanghai elders from 1998 to 2008 in order to explore the health behaviors of Chinese elders during a time of major socioeconomic change. Shanghai is the most populous Chinese city with the nation's highest proportion of senior citizens. In 2008, the local population reached 13.9 million; 15.4% of the population was over 65 years old.²³ Shanghai is also one of the most rapidly urbanized metropolitan areas in China and a showcase of Chinese modernization, both economically and culturally. The investigation period in this study (1998–2008) covers a representative interval of an unprecedented socioeconomic change.²⁴

Methods

Data

Data were from the Shanghai Longitudinal Survey of Elderly Life and Opinion (SLOSELO), a longitudinal investigation of Shanghai's elderly population (60+) administered by Shanghai's Research Center on Aging (SRCA). Four waves of data were collected in 1998, 2003, 2005 and 2008. All information was obtained through in-home interviews by trained staff of the SRCA. Informed consent was obtained from each participant. This study was approved by the Duke University Medical Center IRB.

SLOSELO utilized a stratified, multistage random sample. At baseline (1998), ~1.5 of every 1000 older adults in Shanghai (60+) were sampled ($n = 3525$). According to approximation to the city proper, four geographical zones in Shanghai were delimited. In each zone, three districts were identified; within each district, one street residential committee, town or village was chosen; as a result, 12 investigation sites were determined: downtown (three street residential committees from Huangpu, Xuhui and Yangpu District), peripheral

of the city proper (three street residential committees from Zhabei, Changning and inner part of Pudong District), immediate suburbs (two villages from Jiading and the outer part of Pudong District, one town from Minhang District) and outer suburbs (two villages from Qingpu and Nanhui District, one town from Jinshan District). In each site, three candidate communities were randomly selected, to allow for a sample frame twice the size of the predetermined sampling quota for the site. All qualified elders from the first community were included; if numbers were not adequate, elders from the second and if necessary, the third community, were used. Finally, according to the predetermined gender and age sampling structure, a random sample was selected from the established sample frame. When two or more individuals were from the same family, a random assignment list was applied to retain only one family member. The same strategies were followed in subsequent waves, with the exception that sampling was conducted with replacement for attrition. Respondents from previous waves were always re-interviewed unless they were dead or had moved out of site.

Individuals younger than age 65 were not included in this analysis. Elders in institutions were also excluded due to the extremely low rate of institutionalization in Shanghai (<3%). The consequent total sample size was 9860 in the pooled dataset. Missing data were generally <2%; missing values in the sample were imputed using regression imputation methodology.²⁵

Measurement

Leisure-time physical activity of Shanghai elders was examined in two ways. First, the proportion engaging in 16 major habitual activities were examined. Respondents were asked by a yes/no question about whether they habitually engaged in each of the leisure-time activities, including (i) habits typically not related to physical activity such as watching TV, watching movies, listening to music, reading book or newspapers, calligraphy or painting, collection and appreciation and photography; (ii) habits typically related to at least some physical and/or outdoor activity such as exercise, raising flowers or birds, strolling in the park, and fishing; and (iii) habits related to social activities but that typically require getting out of the home or walking short distances such as chatting with others, playing card or chess, attending traditional opera, singing or dancing and tourism (Cronbach alpha = 0.56). Although we recognize that performance of some of the 'physical' activities in categories ii and iii may seem more social and/or may not involve structured exercise or physical activity in the strict sense, many of them require, at a minimum, leaving the residence and engaging in a short-distance walk, a level of physical activity that has

previously been shown to have protective health effects.²⁶ For this reason, and based on our understanding of Chinese culture and how these activities typically are performed, we decided to loosely group these leisure time activities together in the three ways described above. Finally, each respondent was asked whether he or she regularly exercised in the previous 6 months.

In the trend analysis, the major independent variable, year, was a categorical indicator of each investigation year. To control confounding effects from population and health changes, we included demographic factors such as age and gender, and a series of health covariates (comorbidity, a symptom index, a depression symptom index, cognitive impairment and disability measures such as activities of daily living (ADL) and instrumental activities of daily living (IADL).

The comorbidity index included the presence or absence of physician-diagnosed hypertension, coronary heart disease, stroke, diabetes, bronchitis, cancer, prostatitis and arthritis (score = 0–8, Cronbach alpha = 0.34); the symptom index included low appetite, difficult breathing, stomach pain, dizziness, sleeping problem, constipation, fatigue, swollen joints, chest and/or heart pain, and headache regularly experienced in the previous 6 months (score = 0–10, Cronbach alpha = 0.64).

The depression symptom index was based on seven questions: ‘do you always think optimistically?’, ‘are you often afraid and strained?’, ‘are you feeling lonely?’, ‘are you feeling useless?’, ‘are you as happy as before?’, ‘are you able to make your own decisions?’, ‘do you keep everything clean and organized?’ (score = 0–21 with higher scores indicating more depression symptoms, Cronbach alpha = 0.64). Cognitive impairment was measured using 10 questions including current date and month, date for the Moon Festival on the lunar calendar, serial subtractions from 20 by 3, home address, living district or county, age, number of minutes in an hour, establishment year for the People’s Republic of China, and the name of the first Chinese prime minister (score = 0–10, Cronbach alpha = 0.81).

The ADL index included eight items asking respondents about the difficulty in eating, dressing, moving on and off bed, transferring indoor, washing their face or brushing their teeth, toileting, bathing or moving upstairs and downstairs (Cronbach alpha = 0.93). The IADL index included 10 questions about the difficulty in cooking, washing clothes, cleaning, taking medicine, nailing, managing money, making phone calls, getting outside in rainy weather, shopping and going to doctor (Cronbach alpha = 0.91). Both ADL and IADLs were coded as a dichotomous indicator based on the presence of difficulty with any item.

Finally, in order to explore how economic growth and urbanization may influence the time trend, we also included socioeconomic variables such as self-reported economic status (good/poor) and educational achievement (illiterate/primary and middle school/high school or above) and rural/urban residence.

Analytical strategy

The structure of leisure-time habitual activity of Shanghai elders was initially described by summarizing frequency distributions. Random effect logit models were used to examine trends over time, with control of confounding by demographic and health factors. The panel data of this study contained repeated measurements for each participant, and the random effect logit model allows for correction of intrapersonal correlations through introducing a random intercept for each participant in the model.²⁷ The same modeling strategy was also applied to the trend analysis of regular exercise in the previous 6 months, except that three nested models were used in order to examine the different effects of covariates on the time trend: Model I controlled for demographic variables, Model II added health covariates and the final model included socioeconomic variables. All analyses were performed using Stata/SE 10.0.

Results

Table 1 shows unadjusted proportions engaging in each leisure-time habit across the four investigation years, ordered by frequency in 2008. Watching TV maintained its status as the most common habitual activity in Shanghai elders; the proportion of people regularly watching TV increased from 66 to 78% in the past decade. Other common habitual activities included chatting with others, reading book or newspapers and exercise, all of which were engaged in regularly by at least 25% of all seniors across all study years during the 10-year period. Notably, of these top four leisure-time habits, exercise was the only one with increasingly fewer participants over the 10-year study period. Similar results were also seen for regular exercise in the previous 6 months, the percent of which dropped from 44% in 1998 to 32% in 2008. Among the remaining habits surveyed, strolling in the park, playing cards or chess and raising flowers or birds were engaged in regularly by at least 10–20% of seniors, and most of the other activities were not popular at all (<10%). Listening to music dropped from 15% in 2005 to only 6% in 2008, possibly due to a change in questionnaire wording in 2008 from ‘listening to music’ to ‘listening to music and playing instruments’.

Table 1 Descriptive statistics

Year	1998	2003	2005	2008
Sample size	2763	3222	1680	2195
% Watching TV	65.7	68.3	72.3	77.6
% Chatting with others	37.4	47.7	46.5	44.4
% Reading book or newspapers	28.3	33.4	33.6	37.7
% Exercise	31.9	26.2	27.9	25.3
% Strolling in park	16.0	17.1	16.3	16.1
% Playing card or chess	18.2	16.7	16.9	15.8
% Raising flower or bird	10.8	10.8	8.1	10.4
% Tourism	5.0	6.6	7.7	8.4
% Watching movie	4.6	7.6	8.0	6.9
% Listening to music	19.3	14.4	14.8	6.4
% Playing traditional opera	8.0	3.0	2.9	4.2
% Singing and dancing	2.5	3.0	2.4	3.2
% Calligraphy or painting	2.6	2.4	1.6	2.1
% Fishing	2.4	0.9	1.0	1.8
% Photography	1.1	1.4	1.1	1.1
% Collection and appreciation	0.9	1.0	0.5	0.8
% Regular exercise in the past 6 months	44.2	40.0	33.9	32.3
Mean age (sd)	72.9 (6.2)	73.9 (6.4)	74.4 (6.5)	75.1 (6.5)
% Women	55.5	54.4	54.9	54.3
Mean comorbidity (range = 0–8) (sd)	1.3 (1.2)	1.6 (1.3)	1.6 (1.2)	1.5 (1.2)
Mean unhealthy symptom (range = 0–10) (sd)	2.0 (2.0)	1.8 (2.0)	1.8 (1.6)	1.5 (1.5)
Mean depression symptom (range = 0–21) (sd)	4.2 (3.7)	4.4 (3.5)	3.6 (3.8)	3.9 (3.6)
Mean cognitive impairment (range = 0–10) (sd)	1.2 (1.9)	0.8 (1.7)	0.6 (1.4)	0.6 (1.4)
% Any ADL limitation	15.9	16.9	15.5	14.9
% Any IADL limitation	42.1	39.7	37.6	30.1
% Good economic status	75.2	76.4	76.1	87.0
% 0 year of schooling	48.2	39.3	33.2	28.7
% 1–9 years of schooling	39.0	42.2	46.8	50.3
% 10+ years of schooling	12.8	18.5	20.0	21.0
% Rural residence	31.5	31.5	21.5	9.2

The average age of the sampled elderly population increased from 1998 to 2008, likely reflecting the known local population aging, while the gender structure was fairly stable (Table 1). Health conditions varied differently across waves, though IADL disability consistently improved throughout the past decade. Consistent with rapid economic growth and urbanization in Shanghai, economic status and education improved in each wave of the study compared with previous waves and a rapid decline was observed in the proportion of rural residents.

Table 2 presents adjusted odds ratios for the likelihood of engaging in leisure-time habitual activities for each investigation year relative to the baseline year of 1998, controlled for potential confounding by demographic and health covariates. For leisure-time habits not related to physical activity,

three were increasingly likely over time: watching TV, reading books or newspapers and watching movies, while the odds of listening to music and calligraphy or painting consistently declined. Habits requiring at least some physical activity all declined. This is especially true for the habit of exercise, for which the odds ratio in each observation year compared with 1998 (0.69, 0.39 and 0.36 for 2003, 2005 and 2008, respectively). Leisure-time social activity had a mixed pattern. In the recent decade, Shanghai elders tended to talk more with others and travel more in their leisure time, but were less likely to play cards or chess, or to attend traditional operas.

Table 3 also reveals that Shanghai elders were substantially less likely to engage in regular exercise during the previous 6 months during the time period from 1998 to 2008. As can be seen in Models I and II, when demographic and health

Table 2 Odd ratios of engaging in leisure-time habit of Shanghai elders, 1998–2008

	2003 ^a		2005 ^a		2008 ^a	
	OR	95% CI	OR	95% CI	OR	95% CI
Habit not related to physical activity						
Watching TV	1.04	[0.91, 1.19]	1.17	[1.00, 1.38]	1.78***	[1.51, 2.09]
Reading book or newspapers	1.25*	[1.04, 1.52]	0.96	[0.76, 1.21]	1.45***	[1.16, 1.81]
Watching movie	1.68***	[1.32, 2.13]	1.70***	[1.29, 2.23]	1.46**	[1.12, 1.92]
Listening to music	0.58***	[0.49, 0.68]	0.55***	[0.45, 0.68]	0.19***	[0.15, 0.24]
Calligraphy or painting	0.76	[0.50, 1.16]	0.37**	[0.20, 0.66]	0.53*	[0.31, 0.89]
Photography	1.30	[0.74, 2.27]	0.80	[0.39, 1.63]	0.95	[0.49, 1.84]
Collection and appreciation	0.97	[0.51, 1.86]	0.42	[0.16, 1.09]	0.79	[0.36, 1.72]
Habit related to physical activity						
Exercise	0.69***	[0.60, 0.79]	0.39***	[0.33, 0.47]	0.36***	[0.31, 0.43]
Strolling in the park	1.02	[0.84, 1.22]	0.84	[0.67, 1.06]	0.79*	[0.63, 0.98]
Raising flower or bird	0.90	[0.73, 1.11]	0.51***	[0.38, 0.67]	0.75*	[0.59, 0.97]
Fishing	0.28***	[0.16, 0.48]	0.30**	[0.15, 0.61]	0.69	[0.40, 1.20]
Habit related to social activity						
Chatting with others	1.72***	[1.53, 1.94]	1.56***	[1.34, 1.80]	1.49***	[1.29, 1.71]
Playing card or chess	0.83	[0.68, 1.01]	0.77*	[0.60, 0.98]	0.71**	[0.56, 0.90]
Tourism	1.44**	[1.11, 1.87]	1.42*	[1.06, 1.92]	1.77***	[1.33, 2.35]
Playing traditional opera	0.32***	[0.24, 0.42]	0.28***	[0.20, 0.40]	0.43***	[0.33, 0.58]
Singing or dancing	1.12	[0.75, 1.69]	0.67	[0.40, 1.14]	1.09	[0.68, 1.75]

^aReference is the year of 1998.

* $P < 0.05$.

** $P < 0.01$.

*** $P < 0.001$.

factors were controlled, odds ratios for regular exercise in the previous 6 months decreased in each observation year (0.70, 0.36 and 0.28), in comparison with 1998. It is interesting that this trend did not change much when socioeconomic factors were additionally controlled in Model III. Females were less likely to exercise in Model I; however, the gender effect was reversed when health and socioeconomic variables were controlled. This suggests that the gender difference in regular exercise was at least partly due to health and socioeconomic disparities.

Discussion

Main finding of this study

This study analyzed 10-year trends in leisure-time physical activity of older adult citizens of Shanghai, the largest and most aged city of China. Although not necessarily generalizable to all of China, the observed trends in Shanghai are likely similar to many other Chinese cities, which are experiencing similarly fast economic growth and urbanization. It is possible that such rapid socioeconomic development in

Shanghai may have contributed to changes in the way local elders spend their spare time. New entertainment from TV programs, computers and movies may entice local aged people away from previous pastimes such as listening to music or practicing calligraphy or painting; educational improvement also reduces illiteracy so that elders may have more opportunity to enjoy reading books and newspapers during leisure time. Of concern is that the most common activities are all indoors and sedentary, whereas physical activity and regular exercise are declining over time.

What is already known on this topic?

Regular physical activity has known important health benefits and it has been highly recommended to maintain an active lifestyle in advanced age.²⁸ With the world's population aging at an unprecedented pace, especially in developing countries, facilitating exercise behavior in the elderly population is a prominent issue for public health management.¹⁷ Published reports of leisure-time physical activity changes have been limited to developed nations and generally support a positive trend over time for the elderly population. For example, in

Table 3 Odd ratios of engaging in regular exercise of Shanghai elders, 1998 to 2008

Variables	Model I		Model II		Model III	
	OR	95% CI	OR	95% CI	OR	95% CI
Year: 1998	–	–	–	–	–	–
2003	0.81**	[0.71, 0.93]	0.69***	[0.60, 0.79]	0.70***	[0.61, 0.80]
2005	0.56***	[0.47, 0.66]	0.39***	[0.33, 0.47]	0.36***	[0.30, 0.42]
2008	0.53***	[0.45, 0.62]	0.36***	[0.31, 0.43]	0.28***	[0.24, 0.33]
Age	0.93***	[0.92, 0.94]	0.98***	[0.97, 0.99]	0.98***	[0.97, 0.99]
Female	0.70***	[0.61, 0.80]	1.05	[0.92, 1.19]	1.23**	[1.08, 1.40]
Comorbidity			1.18***	[1.12, 1.25]	1.08**	[1.03, 1.14]
Unhealthy symptom			1.03	[0.99, 1.07]	1.04*	[1.01, 1.08]
Depression symptom			0.91***	[0.89, 0.93]	0.92***	[0.90, 0.94]
Cognitive impairment			0.66***	[0.62, 0.70]	0.79***	[0.75, 0.84]
ADL disability			0.44***	[0.36, 0.54]	0.39***	[0.32, 0.48]
IADL disability			0.73***	[0.64, 0.84]	0.81**	[0.71, 0.93]
Financial status						
Not good					–	–
Good					1.42**	[1.22, 1.65]
Education						
No schooling					–	–
1–9 year schooling					1.46***	[1.26, 1.70]
10+ year schooling					1.95***	[1.60, 2.37]
Rural residence					0.23***	[0.20, 0.28]
Rho	0.41		0.31		0.26	
LL	6167.81		5805.23		5541.39	

* $P < 0.05$.** $P < 0.01$.*** $P < 0.001$.

the USA, the proportion of elderly people (65+) reporting no leisure time physical activity in the previous month dropped from 34.2% in 2001 to 32.7% in 2007 and the proportion of elders with 30+ min of moderate physical activity five or more days per week or vigorous physical activity for 20+ min three or more days per week increased from 36.1% in 2001 to 40.3% in 2009.²⁹ In Canada, the proportion of seniors accumulating an average of 3.0+ MET-hours leisure time physical activity daily increased from 18.8 to 30.7% from 1981 to 2000.³⁰ In Britain, an upward trend in regular sports participation was also found in the elderly population, the mean weekly time spent in moderate to vigorous-intensity sports increased steadily from 1993 to 2004.³¹

What this study adds?

The temporal change in physical activity we observed in Shanghai elders is opposite to the general trends of the western countries. The current study draws attention to the

need for more work on the dynamics of physical activity trends for elders in developing societies. It also highlights an important problem for clinical and public health providers in Shanghai. Our data showed there was a decrease in leisure time physical activity of elders in Shanghai. We believe our findings point to a need for more effective lifestyle interventions for local seniors, who are becoming increasingly sedentary. Encouragement to engage in physical activity could effectively help reduce public expense and medical service use by the local aged population.³²

More interestingly, our work suggests a health paradox currently existing in Shanghai: local elders have become increasingly inactive over the recent decade, even as they have enjoyed many benefits of the recent economic growth, medical and public health reforms in the elder care sector. Older adults currently are functionally healthier than in past years.³³ However, the subtle coexistence of a sedentary lifestyle and improvements in functional health may not be sustainable. Sooner or later, negative long-term effects of a

sedentary lifestyle may counter the medical and public health efforts toward improved functional health. We therefore highlight a need for cities such as Shanghai to focus public health efforts toward physical activity promotion and health prevention programs for local elders.

Limitations of this study

The current study had a number of limitations. Due to restrictions in funding in 2005 and 2008, the sample size was slightly <1.5% of the total elderly population. Nevertheless, case numbers were adequate to power the current analysis. Our analysis also focused on local residents with official registration, but did not survey immigrants, who also consume local public health resources. Similarly, elders in institutions were excluded though this is a sub-population that has been growing rapidly in recent years. Future studies may pay greater attention to these issues. In addition, our analysis was dependent on existing data which previously had been collected by Chinese government researchers; we were not able to validate some of the measurements, and most, including leisure-time physical activity, relied on self-reported results, with residual potential for self-report error/recall bias. Moreover, the validity of some index measurements such as depression symptom index was not well established in China. We did attempt where possible to add measures of internal consistency to our analysis, but further work may be needed to verify our findings. Finally, the socioeconomic factors we included in our models may not have adequately reflected the macro-social changes of Shanghai compared with other regions, which has largely driven some of the changes in the lifestyle of Shanghai elders. Future surveys of more representative areas of China and in other developing nations will be needed to explore this important aspect.

Authors' contribution

J.L.P. and Q.F. contributed equally to the study design, analysis and interpretations of data. Z.Z. supported the data acquisition. P.W.D. and Z.Z. provided suggestions and comments on the analysis. Q.F. drafted the paper. P.W.D. and J.L.P. revised it for important intellectual content.

Funding

The authors thank the Global Aging and Population Sciences Research RFP of the Duke Global Health Institute, Duke University.

References

- 1 Gu MO, Conn VS. Meta-analysis of the effects of exercise interventions on functional status in older adults. *Res Nurs Health* 2008;**31**:594–603.
- 2 Lopopolo RB, Greco M, Sullivan D *et al*. Effect of therapeutic exercise on gait speed in community-dwelling elderly people: a meta-analysis. *Phys Ther* 2006;**86**:520–40.
- 3 Middleton LE, Mitnitski A, Fallah N *et al*. Changes in cognition and mortality in relation to exercise in late life: a population based study. *PLoS ONE* 2008;**3**:e3124.
- 4 Ströhle A. Physical activity, exercise, depression and anxiety disorders. *J Neural Transm* 2009;**116**:777–84.
- 5 Pescatello LS, Franklin BA, Fagard R *et al*. Exercise and hypertension. *Med Sci Sports Exerc* 2004;**36**:533–53.
- 6 Seals DR, DeSouza CA, Donato AJ *et al*. Habitual exercise and arterial aging. *J Appl Physiol* 2008;**105**:1323–32.
- 7 Orozco LJ, Buchleitner AM, Gimenez-Perez G *et al*. Exercise or exercise and diet for preventing type 2 diabetes mellitus. *Cochrane Database Syst Rev* 2008;**3**:CD003054.
- 8 Bosomworth NJ. Exercise and knee osteoarthritis: benefit or hazard? *Can Fam Phys* 2009;**55**:871–8.
- 9 Tanaka H. Habitual exercise for the elderly. *Fam Community Health* 2009;**32**(Suppl.):57–65.
- 10 U.S. Department of Health and Human Services. *Physical Activity and Health: A Report of the Surgeon General*. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, 1996.
- 11 Kahn EB, Ramsey LT, Brownson RC *et al*. and the Task Force on Community Preventive Services. The effectiveness of interventions to increase physical activity: a systematic review. *Am J Prev Med* 2002;**22**:73–107.
- 12 Heath GW, Brownson RC, Kruger J *et al*. and the Task Force on Community Preventive Services. The effectiveness of urban design and land use and transport policies and practices to increase physical activity: a systematic review. *J Phys Act Health* 2006;**3**(Suppl.):55–76.
- 13 Lippke S, Ziegelmann JP, Schwarzer . Stage-specific adoption and maintenance of physical activity: testing a three-stage model. *Psychol J Sport Exerc* 2008;**6**:585–603.
- 14 Matsudo V, Matsudo S, Andrade D *et al*. Promotion of physical activity in a developing country: the Agita São Paulo experience. *Public Health Nutr* 2002;**5**:253–61.
- 15 Sarrafzadegan N, Kelishadi R, Esmaillzadeh A *et al*. Do lifestyle interventions work in developing countries? Findings from the Isfahan Healthy Heart Program in the Islamic Republic of Iran. *Bull World Health Organ* 2009;**87**:39–50.
- 16 Kinsella K, He W. U.S. Census Bureau, International Population Reports, P95/09–1. An Ageing World: 2008. Washington, DC: U.S. Government Printing Office, 2009.
- 17 Shilton TR. Creating and making the case: global advocacy for physical activity. *J Phys Act Health* 2008;**5**(6):765–76.

- 18 Bull FC, Pratt M, Shepherd RJ *et al.* Implementing national population based action on physical activity for action and opportunities for international collaboration. *Promot Educ* 2006;**13**: 127–32.
- 19 Popkin BM. The nutrition transition in the developing world. *Dev Policy Rev* 2003;**21**(5–6):581–97.
- 20 Flaherty JH, Liu ML, Ding L *et al.* China: the aging giant. *J Am Geriatr Soc* 2007;**55**(8):1295–300.
- 21 Hsiao WCL, Liu Y. Economic reform and health: lessons from China. *N Engl J Med* 1996;**335**:430–2.
- 22 Matthews CE, Jurj AL, Shu X *et al.* Influence of exercise, walking, cycling, and overall nonexercise physical activity on mortality in Chinese women. *Am J Epidemiol* 2007;**165**:1343–50.
- 23 Shanghai Statistics Bureau. *Shanghai Statistics Yearbook 2009*. Beijing: China Statistics Press, 2009. (in Chinese)
- 24 Shanghai Statistics Bureau. *Shanghai Statistics Yearbook 2000*. Beijing: China Statistics Press, 2000. (in Chinese)
- 25 Allison P. *Missing Data*. Thousand Oaks, CA: Sage Publications, 2002.
- 26 Simonsick EM, Guralnik JM, Volpato S *et al.* Just get out the door! Importance of walking outside the home for maintaining mobility: findings from the women's health and aging study. *JAGS* 2005;**53**:198–203.
- 27 Raudenbush S, Bryke A, Cheong YF *et al.* *HLM: Hierarchical Linear and Nonlinear Modeling*. Lincolnwood, IL: Scientific Software International, Inc, 2004.
- 28 Nelson ME, Rejeski WJ, Blair SN *et al.* Physical activity and public health in older adults: recommendation from the American College of Sports Medicine and the American Heart Association. *Med Sci Sports Exerc* 2007;**39**:1435–45.
- 29 Centers for Disease Control and Prevention. *Behavioral Risk Factor Surveillance System Survey Data*. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, 2010.
- 30 Craig CL, Russell SJ, Cameron C *et al.* Twenty-year trends in physical activity among Canadian adults. *Can J Public Health* 2004;**95**:59–63.
- 31 Stamatakis E, Ekelund U, Wareham NJ. Temporal trends in physical activity in England: The Health Survey for England 1991 to 2004. *Prev Med* 2007;**45**:416–23.
- 32 Fries JF, Koop CE, Beadle CE *et al.* The Health Project Consortium. Reducing health care costs by reducing the need and demand for medical services. *N Eng J Med* 1993;**329**:321–5.
- 33 Feng Q, Gu D, Zhen Z *et al.* Trends of ADL and IADL disability in Shanghai older adults, 1998 to 2008. *J Gerontol B Psychol Sci Soc Sci* (under review).