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Re-Examining the Role of Engaging in Activities: Does its Effect on Mortality Change by Age among the Chinese Elderly?

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Abstract Engaging in activities has been found beneficial overall to individuals' well-being. What has not been systemically tested with large sample data is whether such benefits diminish at very old ages. This study uses the Chinese Longitudinal Health Longevity Survey (CLHLS) between 2002 and 2008 to test how the effect of engaging in activities on mortality changes by age among the elderly. Approximately half of the 16,064 people aged 65 and over interviewed in 2002 died within the following six-years. Two types of activities are examined: customary physical activities, such as such as doing housework and gardening, and social activities, such as playing cards and attending organized activities. The Cox model is applied to analyze the hazards of mortality. Both physical and social activities are found to reduce the hazards of mortality for the whole sample and both activities showed a negative interaction effect with age. As age increases, their beneficial effects decrease. These patterns are also evident in the sub-sample analysis by age and gender. Although many studies have shown the beneficial effect of engaging in activities for individuals' well-being, as is well reported in the media, these results suggest a diminishing effect at old ages.

Keywords Mortality · Customary activity · Social activity · Aged · China

The study of the oldest-old is one of the new frontiers of research as the elderly population itself is aging (Baltes and Smith 2003; Cohen-Mansfield 2011). Investigating whether the common recommendation given to the elderly population – staying engaged in activities – applies to the elderly at very old ages, 80 or above, has both theoretical and practical significance.

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The world's population is aging rapidly, resulting from both longer life expectancy and lower birth rates in both developed and developing countries. The global elderly population aged 60 and over is projected to grow from 901 million in 2015 to 1.4 billion in 2030 and likely to reach 2.1 billion by 2050 (United Nations 2015). Although developed nations witnessed higher proportion of the elderly in their populations, over half of the world's elderly live in developing nations, where the pace of population aging is even faster. Meanwhile, the elderly population itself is aging. The oldest old, often defined as people aged 80 or 85 and over, are the fastest-growing portion of the population in many countries. Globally, the number of people over age 80 will more than triple from 125 million in 2015 to 434 million in 2050 (United Nations 2015).

Worldwide, great effort has been made to find what factors, socioeconomic, behavioral, environmental, or cultural, can contribute to maintaining the elderly's well-being. One commonly held recognition is the benefit of engagement for the elderly. Engaging in various leisure activities, either physical or social, has been found to be beneficial to the elderly's well-being, such as physical, cognitive performance, the onset of dementia, and mortality (Lennartsson and Silverstein 2001; Saczynski et al. 2008; Taaffe et al. 2008; Zunzunegui et al. 2003). Physical activity has been found to be inversely related to all-cause mortality (Lee and Skerrett 2001; Rowe et al. 2005; Samitz et al. 2011). The underlying mechanisms can be due to its influence on physiological capacity, psychological health, and risk factors for chronic disease, including decreased body fat and estrogen levels for preventing cancer and increased bone density and muscle mass for preventing osteoporosis (Singh 2002). A recent literature review suggests that leisure activity brings about both external (greater range of motion and muscle tone) and internal (better digestion and cardiovascular functions) benefits to health (Adams et al. 2011). National guidelines have been issued to encourage individuals of all ages to engage in frequent and appropriately intense physical activity (American College of Sports Medicine 1998; Nelson et al. 2007). Although higher intensity activities have been reported to bring more reduction in mortality than either lower intensity activities or non-activity (Lee and Paffenbarger 2000; Matthews et al. 2007), domestic or leisure activity (such as housework and gardening), which is less physically intense, has been found beneficial to health and survival as well (Besson et al. 2008; Brown et al. 2012; Samitz et al. 2011; Woodcock et al. 2011).

Social engagement, including getting together with friends and attending social functions, enhances social support, behavioral modification, and access to resources and material goods (Berkman et al. 2000). Higher levels of social activity were found to be related with better health and lower mortality risk (Bath and Deeg 2005; Bygren et al. 1996; Maier and Klumb 2005). Positive social interactions were found to be associated with physiological profiles characterized by lower levels of stress hormones, decreased cardiovascular activity, and boosted immune function (Seeman 2000). Elders engaging in social activity receive multidimensional benefits: greater social support, information on health behaviors and access to health care, and increased self-esteem and sense of belonging, all of which improve health status and reduce the likelihood of death (Holmes and Joseph 2011). Playing mah-jong and other card games with others, as a type of social activity, can be cognitively stimulating, bolster intellectual skills, and

reinforce mental acuity (Ross and Zhang 2008). Other social activity pathways include emotional closeness and enhanced cognitive reappraisals that reduce the stressfulness of stressful situations (Adams et al. 2011).

Most of these findings, however, are based on samples from the general population that covers a wide range of age distribution, and treat the elderly as a single age group, paying less attention to the heterogeneity among the elderly themselves, such as the difference between the young-old, old, and oldest-old (Arem et al. 2015; Bucksch 2005; Lollgen et al. 2009; Moore et al. 2012). The empirical evidence seems less consistent for the elderly population. While physical or social activity was found significant in affecting the elderly's survival in some studies (Bagiella et al. 2005; Lee and Paffenbarger 2000; Yeager et al. 2006), they were found insignificant in others (Rodriguez-Laso et al. 2007; Wilkins 2003). Most studies that included the elderly in their sample tended to draw the age distinction between the middle aged (under age 60 or 70) and the older, or to use age as a control variable in the analysis of an elderly sample, assuming the effect of physical or social activity to remain the same for the entire elderly population (Anderson et al. 2000; Singh 2002; Sundquist et al. 2004; Veenstra and Patterson 2012). Although there are findings documenting the diminishing protective effect of physical activity on mortality by age among the elderly (Lindsted et al. 1991; Maier and Klumb 2005), there is lack of attention in the mainstream literature about how the beneficial effect of engaging in physical or social activity varies by age among the elderly themselves.

There is also evidence that the association between domestic physical or social activity and mortality may be conditional on gender. For example, women were found to receive more protective benefits from engaging in physical or social activity than men (Brown et al. 2012; Lollgen et al. 2009; Samitz et al. 2011). In one study, church attendance conferred longer survival to women aged 70 or over but not to men (Oman et al. 2002).

There have been studies that include leisure activities in their analyses using the Chinese Longitudinal Health Longevity Survey (CLHLS), the dataset that this paper is built upon. Gardening, playing cards or mah-jong, watching TV, and listening to the radio were found to delay the onset of cognitive impairment (Zhang 2006). Engaging in leisure activities was found to increase psychosocial well-being and reduce the probability of experiencing ADL difficulties (Sun et al. 2009). And engaging in leisure activities could partially account for the association between religious participation and lower mortality risk (Zhang 2008). Sun and Liu (2006) examined how leisure activities affected mortality between 1998 and 2000 and found an overall beneficial effect of such activities. But all these studies were restricted to the oldest old only – those aged 80 or above. Zeng et al. (2010) constructed a leisure activity index from seven activities and showed that participating in leisure and religious activities significantly reduced the probability of ADL disability, cognitive impairment, the cumulative health deficit index, and mortality. Although it included both young and oldest old, this study did not look at how these significant effects changed by age.

Using the Chinese Longitudinal Health Longevity Survey (CLHLS), this study explores two research questions: 1) Does the association between engaging in domestic physical or social activities and survival vary by age among the Chinese elderly? 2) How does such association vary by gender?

Methods

CLHLS, jointly conducted by Peking University and Duke University, is a national, longitudinal survey of the Chinese elderly, originally designed to include people aged 80 and older. It covered 22 randomly selected provinces in China. It has so far collected six waves of data in 1998, 2000, 2002, 2005, 2008, and 2012. Starting in 2002, it was expanded to include respondents aged 65–79. In order to cover the whole age range of the elderly population, this study uses data from years 2002 to 2008. Of the 16,064 respondents interviewed in 2002, in the 2005 follow-up 5874 elderly died, 8175 survived, and 2015 cases were missing. In the 2008 follow-up, 2520 elderly died, 4191 survived, and 1464 cases were missing. In the following survival analysis, while the 2015 missing cases from 2005 were removed, the 1464 missing cases from 2008 were coded as censored in 2005. In addition, there were 408 cases missing on the dates of death and 266 cases missing on the sample weight. Removing these cases results in a final sample size of 13,375. All information was obtained through in-home interviews. Systematic assessments of the CLHLS indicate that the data quality is good (Gu 2008; Gu and Dupre 2008; Zeng and Gu 2008). The weights created for the 2002 sample were applied in the descriptive and survival analysis.

The dependent variable is the hazard of death between 2002 and 2008. The duration of survival was measured in days from the baseline in 2002. The values of all the independent variables were initially taken from the baseline interview in 2002. The measures for those elderly who were still alive and interviewed in 2005, were updated with information from 2005.

Physical activity was measured by two variables: exercise or less intensive domestic physical activity. In the survey, the respondent was asked "Do you do exercise regularly at present?" "Yes" is coded as 1 and "No" as 0. Domestic physical activity comprised four specific activities: housework, gardening, raising domestic animals, and other outdoor activities. Each specific activity is indexed at five levels: 0 = *never*, 1 = *not every month*, 2 = *not every week,* 3 = *not everyday*, and 4 = *almost everyday*. A score for domestic physical activity was created by summing the index of each specific activity and ranged from 0 to 16.

Social activity was measured by three activities, including playing cards or mahjong, taking part in organized activities, and attending religious activities. Since the involvement in these activities is highly skewed (64% of the elderly in 2002 and 72% in 2005 reported never attended any of these activities), social activity was recoded as a binary outcome: 0 = *never* and 1 = *sometimes*.

The following ten measures were included to control health status at the baseline. 1) Self-rated health was measured at five levels: 1 = *very bad*, 2 = *bad*, 3 = *so so*, 4 = *good*, and 5 = *very good* (*unable to answer* was treated as *very bad*) 2) Perceived change in health status compared with last year was coded in three categories: 0 = *worse*, 1 = *no change*, and 2 = *better* (*unable to answer* was treated as *worse*). 3) Self-rated quality of life was measured at five levels: 1 = *very bad*, 2 = *bad*, 3 = *so so*, 4 = *good*, and 5 = *very good* (*unable to answer* was treated as *very bad*). 4) Activities of Daily Living (ADL) was composed of the following six basic personal-care activities: bathing, dressing, eating, indoor transferring, toileting, and continence. Each activity was recoded at two levels: 0 = *receiving assistance* and 1 = *receiving no assistance*. The ADL index was the sum of all six activity scores ranging from 0 to 6 with higher index suggesting better

ADL. 5) Instrumental Activities of Daily Living (IADL) was measured by ability to perform the following eight activities: visiting neighbors, shopping, cooking, washing clothes, walking one kilometer, lifting five-kilograms, crouching and standing up three times, and taking public transportation. Each activity was recoded at two levels: 0 = *unable independently* and 1 = *able independently*. The IADL index, the sum of all eight activity scores, ranges from 0 to 8 with higher scores suggesting better IADL. 6) Upper extremities were measured by ability to do the following three moves: able to put hands behind neck, to put hands behind lower back, and to raise arms upright. Each move was coded as binary: 0 = *unable with both hands* and 1 = *able with both hands*. The index, created by summing up all three moves, ranged from 0 to 3. 7) Lower extremity was measured by a single move: ability to stand up from sitting in a chair. It was coded as a binary variable: 0 = *unable or able with using hands* and 1 = *able without using hands*. 8) Physical performance was measured by two variables: able to pick up a book from the floor from a standing position and able to turn around 360 degrees without help within ten steps. An index was created ranging from 0 to 2 with higher score suggesting better performance. 9) Suffering from any illness in the past 2 years was coded as a binary variable: 0 = *none* and 1 = *any*. 10) Cognitive impairment was measured by the Mini-Mental Status Examination (MMSE), which covers 24 specific items falling in the following five aspects of cognitive functioning: orientation, registration, attention and calculation, recall, and language. It was adapted to the cultural and socioeconomic conditions in China (Zeng and Vaupel 2002). For example, the respondents were asked to name as many foods as possible instead of to write a sentence, which is an impossible task for many members of this age group, many of whom are illiterate. MMSE was measured by an index ranging from 0 to 24 with higher scores suggesting better performance.

Of the socio-demographic variables, age was measured as actual age in years in 2002. Gender was coded as 0 = *female* and 1 = *male*. Because 62% of the elderly in this sample did not report any schooling, educational attainment was categorized as a binary variable: 0 = *illiterate* and 1 = *literate*). Urbanity was coded as a binary variable: 0 = *rural* and 1 = *urban*. Marital status was also coded as a binary variable: 0 = *not married* and 1 = *married*. Living arrangements were coded into three categories: 0 = *living alone or with spouse only* as the reference category, 1 = *living with other relatives*, and 2 = *living in a nursing home*. Whether the elderly had sufficient income to cover daily expenses was measured by 0 = *no* or 1 = *yes*. Whether the elderly received adequate medical services when sick was also coded as either 0 = *no* or 1 = *yes*. Ever smoking was coded as 0 = *no* and 1 = *yes*. Ever drinking was coded as 0 = *no* and 1 = *yes*. The frequency of eating fresh vegetables was coded as 0 = *occasionally or never* and 1 = *everyday or quite often*.

The Cox hazard model was adopted to analyze survival in the 6-year interval between 2002 and 2008 (Allison 1984). As mentioned above, for those who survived to 2005, their characteristics in 2002 was updated by information in 2005. Thus, the covariates were allowed to be time-varying for these subjects. Since there is evidence that the association between domestic physical or social activity and mortality may be conditional on gender, all the analyses were also conducted by gender. The first set of analyses was based on the whole sample. Model 1 examined the main effects of domestic physical activity and social activity with all other covariates controlled. Model 2 added the interaction effects of age with two activity variables to Model 1. For further

insight into the age patterns, in the second set of analyses, the main effects of the activity variables were re-examined with the whole sample broken down by four age groups: 65–74, 75–84, 85–94, and 95 or older with all other covariates controlled.

Results

As shown in Table 1, there was a clear upward trend in the percentage of death within the six-year interval from the youngest to the oldest, from 17.3% for those aged 65–74 to 87.2% for those 95 or older. At the same time, the average duration of survival decreased from 1893 days to 959 days for the two same age groups. In parallel, there was a steady decline in domestic physical activity, from 9.0 for the 65–74 age group to 7.6, 5.1, and 3.3 for the three older groups respectively. There was a similar trend for engaging in social activities. Elderly men were more active than women in all three domains of activity. They were more likely than women to be literate, married, and in better health in virtually all dimensions and had more exposure to smoking and drinking.

Table 2 presents the survival analysis result for the whole sample and by gender. Note that while only age, gender and two activity variables are presented, all other covariates were controlled for in both models. Model 1 shows that, except for domestic

Table 1 Weighted sample characteristics in 2002 by age

	65–74 (n = 2774)		75–84 (n = 3139)		85–94 (3778)		95 + (n = 3684)	
	M	SD	M	SD	M	SD	M	SD
Duration of survival (days)[a,***]	1893.0	1055.4	1664.1	750.1	1314.9	292.9	958.6	51.7
Domestic physical[a,***]	9.0	6.5	7.6	4.3	5.1	1.7	3.3	0.3
Self-rated health	2.5	1.7	2.3	1.0	2.2	0.4	2.0	0.1
ADL[a,***]	5.9	0.9	5.8	0.9	5.3	0.6	4.7	0.2
IADL[a,***]	7.3	2.8	6.1	2.7	4.1	1.2	2.3	0.2
Performance[a,***]	1.9	0.7	1.7	0.7	1.3	0.3	1.0	0.1
MMSE[a,***]	21.8	5.0	20.1	5.1	16.8	2.7	12.7	0.6
Death[b,***]	17.3%		37.6%		64.7%		87.2%	
Exercise[b,***]	37.5%		33.4%		29.3%		20.1%	
Social activity[b,***]	52.5%		44.9%		33.8%		23.0%	
Male[b,***]	50.4%		43.2%		32.6%		25.4%	
Literate[b,***]	53.1%		39.6%		29.5%		22.1%	
Urban[b,**]	32.7%		29.9%		32.4%		38.1%	
Married[b,***]	67.3%		41.3%		17.9%		6.0%	
Living alone/with spouse[b,***]	47.3%		38.8%		26.2%		15.4%	
Living with others[b,***]	51.8%		57.8%		67.7%		79.5%	
Living in a nursing home[b,***]	1.0%		3.4%		6.1%		5.1%	
Sufficient income[b,*]	80.4%		78.0%		79.0%		79.9%	
Adequate medical service[b,***]	92.3%		90.3%		88.0%		84.6%	
Illness[b,***]	13.9%		18.6%		17.8%		18.4%	
Smoking[b,***]	41.7%		36.1%		30.6%		23.4%	
Drinking[b,***]	34.7%		30.6%		30.6%		27.9%	

*** $P < .001$, ** $P < .01$, * $P < .05$

[a] ANOVA F test for numerical variables

[b] Chi-square test for categorical variables

Table 2 Survival analysis of the whole sample and sub-samples by gender, Hazard Ratios (HR)

	Whole sample				Males				Females			
	Model 1		Model 2		Model 1		Model 2		Model 1		Model 2	
Variable	HR	*P-value*	HR	*P-value*	HR	*P-value*	HR	*P-value*	HR	*P-value*	HR	*P-value*
Exercise	0.911	**0.048**	0.795	0.650	0.913	0.150	0.651	0.544	0.911	0.181	1.373	0.668
Domestic physical activity	0.974	**<0.001**	0.756	**<0.001**	0.986	0.097	0.718	**<0.001**	0.957	**<0.001**	0.745	**<0.001**
Social activity	0.860	**0.001**	0.260	**0.006**	0.882	**0.046**	0.361	0.151	0.853	**0.019**	0.225	**0.033**
Age	1.058	**<0.001**	1.035	**<0.001**	1.064	**<0.001**	1.035	**<0.001**	1.052	**<0.001**	1.030	**<0.001**
Male	1.318	**<0.001**	1.294	**<0.001**	----	----	----	----	----	----	----	----
Literate	0.980	0.664	0.996	0.922	1.006	0.925	1.017	0.780	0.955	0.516	0.971	0.674
Urban	1.003	0.948	1.006	0.896	1.009	0.889	1.020	0.756	1.002	0.976	0.998	0.980
Married	0.965	0.443	0.976	0.591	0.925	0.210	0.926	0.215	0.974	0.694	0.990	0.875
Living with others	1.173	**<0.001**	1.189	**<0.001**	1.302	**<0.001**	1.326	**<0.001**	1.032	0.626	1.037	0.565
Living in a nursing home	1.601	**<0.001**	1.621	**<0.001**	1.363	**0.047**	1.377	**0.041**	1.834	**<0.001**	1.875	**<0.001**
Sufficient income	0.944	0.221	0.946	0.232	0.755	**<0.001**	0.754	**<0.001**	1.182	**0.014**	1.189	**0.011**
Adequate medical service	0.983	0.778	0.984	0.786	1.071	0.435	1.065	0.475	0.893	0.179	0.896	0.194
Better self-rated health	0.853	**<0.001**	0.853	**<0.001**	0.816	**<0.001**	0.817	**<0.001**	0.891	**<0.001**	0.890	**<0.001**
Better ADL	0.941	**<0.001**	0.932	**<0.001**	0.926	**0.004**	0.924	**0.003**	0.945	**0.017**	0.931	**0.003**
Better IADL	0.870	**<0.001**	0.871	**<0.001**	0.850	**<0.001**	0.848	**<0.001**	0.894	**<0.001**	0.896	**<0.001**
Better physical performance	0.963	0.298	0.963	0.290	0.954	0.382	0.955	0.397	0.970	0.533	0.972	0.562
Presence of illness	1.048	0.320	1.033	0.495	0.966	0.607	0.950	0.456	1.109	0.123	1.090	0.201
MMSE	0.994	0.110	0.993	0.061	1.003	0.641	1.002	0.680	0.986	**0.006**	0.985	**0.003**
Smoking	1.204	**<0.001**	1.199	**<0.00**	1.164	**0.019**	1.154	**0.027**	1.251	**0.003**	1.251	**0.003**
Drinking	1.020	0.654	1.024	0.600	1.146	**0.019**	1.147	**0.019**	0.859	**0.043**	0.861	**0.047**
Exercise*Age	----	----	1.002	0.791	----	----	1.004	0.644	----	----	0.995	0.578
Domestic physical*Age	----	----	1.003	**<0.001**	----	----	1.004	**<0.001**	----	----	1.003	**<0.001**
Social*Age	----	----	1.016	**0.015**	----	----	1.012	0.206	----	----	1.018	0.057

The reference category is "rural" for "urban"; "currently not married" for "married"; "living alone or with a spouse" for "living with others" and "in a nursing home"

Values highlighted in bold correspond to *p*-values less than 0.05

physical activities for males, both domestic physical and social activities significantly reduced the hazard of death when age-interaction effects were not considered. For example, a one-point increase in domestic physical activity index reduced death hazard by 3% (95% confidence interval (CI): 0.96, 0.98) when both males and females were combined. The results are similar for separate male and female samples.

The added age interaction effects with both domestic physical and social activities were significant for the male/female combined sample in Model 2. The hazard ratios for both interaction effects are greater than 1 (The more precise hazard ratio for the interaction effect of domestic activity and age is 1.004 (95% CI: 1.002, 1.005)), suggesting that as age increases the beneficial effects of both domestic physical and social activities decrease. When the whole sample was broken down by gender, the interaction effect of age and domestic physical activity was still significant for either males or females, although the interaction effect of age and social activity was not significant.

The results above showed some evidence of existing interaction effects of age and the two activity variables, but Model 2 assumes that the interaction effects are evenly distributed by age, which may not be true. Table 3 shows results of the analysis that tries to overcome this problem by breaking down the whole sample into four age groups: 65–74, 75–84, 85–94, 95 and above. The results show that domestic physical activities were significant only for the two youngest age groups: 65–74 and 75–84 when males and females were combined, with a hazard ratio of 0.97 (95% CI: 0.95, 0.98) and 0.97 (95% CI: 0.95, 0.99) respectively. Social activity was significant only for the 65–74 age group with a hazard ratio of 0.83 (95%

Table 3 Survival analysis of sub-samples by age and gender, Hazard Ratios (HR)

Variables	Males + Females		Males		Females	
	HR	*P-value*	HR	*P-value*	HR	*P-value*
65–74						
Exercise	0.924	0.241	0.842	**0.050**	1.068	0.523
Domestic physical activity	0.968	**<0.001**	0.975	**0.028**	0.963	**0.006**
Social activity	0.828	**0.004**	0.892	0.187	0.764	**0.009**
Sample size	2774		1431		1343	
75–84						
Exercise	0.933	0.347	1.016	0.875	0.845	0.125
Domestic physical activity	0.974	**0.005**	0.999	0.948	0.946	**<0.001**
Social activity	0.917	0.228	0.887	0.234	0.930	0.483
Sample size	3139		1600		1539	
85–94						
Exercise	0.874	0.375	0.892	0.622	0.852	0.430
Domestic physical activity	0.980	0.320	0.993	0.820	0.975	0.341
Social activity	0.925	0.608	0.977	0.925	0.899	0.592
Sample size	3778		1732		2046	
95 +						
Exercise	0.883	0.864	0.778	0.846	0.956	0.960
Domestic physical activity	1.007	1.944	0.997	0.986	1.012	0.913
Social activity	0.905	0.890	0.830	0.900	0.935	0.937
Sample size	3684		990		2694	

In all the models, control variables include education, place of residence, marital status, living arrangements, sufficiency of income, adequacy of medical services, self-rated health, ADL, IADL, physical performance, illness, MMSE, smoking, and drinking

Values highlighted in bold correspond to *p*-values less than 0.05

CI: 0.73, 0.94). The female sample shows the same pattern but, for the male sample, only physical activities were significant for the 65–74 age group only.

Discussion

As world population ages rapidly, how to maintain the health of the elderly population becomes an imperative subject. Physical and social activities have been found to be inversely related to all-cause mortality in many studies conducted in more developed countries. Although this study finds a similar pattern in China: engaging in domestic physical or social activity is beneficial to survival of the Chinese elderly aged 65 and above, the beneficial effects of activities are not uniform across all ages or gender among the elderly. While the beneficial effect of domestic physical activities remains significant up to the 75–84 age group, it is only up to the 65–74 age group for social activities when both males and females are combined. And there is a gender difference as well: domestic activities show a beneficial effect for females up to the 75–84 age group, but for males only for the 65–74 age group. Social activities are significant only for females for the 65–74 age group, but not significant for males.

From the statistical point of view, one might attribute the insignificance of the activity variables in higher ages to low participation in these activities, which would increase the standard error of the estimates. But data showed that this was not likely to be the case. For example, participation in social activities for the four age groups shown in Table 1 in 2002 was 52.5%, 44.9%, 33.8%, and 23.0% respectively. It was not terribly low even for the oldest age group. And the effects of activity variables were significant for females rather than males, who were more engaged in these activities.

In the literature on physical activity, there are studies designed to identify the minimum threshold with regard to intensity, frequency, and duration (Reddigan et al. 2011; Sabia et al. 2012; Singh 2002; Sundquist et al. 2004), but much less attention is given to the threshold of age, after which the benefit of activity starts to decrease or disappear. The findings of this study highlight the importance of the possible modifying effect of age on the impact of physical and social activities among the elderly. There was similar evidence in some of the past studies, although it was not explicitly discussed by the authors. In a 26-year follow-up mortality study of 9484 Seventh-Day Adventist Men from 1960 to 1985, the protective effect of moderate activity compared with inactivity on all-cause mortality remained significant to age 89 years and that of high activity remained significant only to age 69 years, where subjects were grouped in 10-year intervals from 50 to 99 years old (Lindsted et al. 1991). In that study, of the five major causes of death, compared with those physically inactive, those who were moderately active had significantly lower hazard ratio up to age 79 for ischemic heart disease, but the hazard ratios were not significant for cerebrovascular disease, arteriosclerosis, other cardiovascular disease, and cancer. Those highly active showed virtually no advantage in survival compared with those inactive for any of the five specific causes.

A 15-year follow-up study of elderly aged 65 and older in Sweden found that social activities and total activities, which includes both social and mental activities (such as reading, watching movies, hunting and fishing) were significant in

preventing dementia only in the first five years after the baseline, but not significant in later years (Sorman et al. 2014), which means such effects disappeared after respondents in the entire sample passed the age of 70. The authors also reported that many other studies that found protective effects of social and mental activities for the elderly only covered a relatively short period of time. In the end, the authors concluded that there was little evidence that "frequent engagement in leisure activities among elderly serves to protect against dementia diseases across a longer time frame" (P500). An Older Australian Twins Study of neurocognitive performance, where subjects were aged 65 or older, physical leisure activity was found not to be related to performance on any cognitive domain, and social activity was significant with only one out of five domains (Lee et al. 2014).

Social participation, indicated by visiting others, going to social gatherings, and attending clubs and other social organizations, was found not to be significant for either men or women in an Austrian sample of people aged 70 or over (McCallum et al. 1994). Visiting friends and family significantly reduced the hazard of mortality for those aged between 65 and 85 of a British sample (RR = 0.81, 95% CI: 0.66, 1.00), but was not significant for those aged 85 or above (Bowling and Grundy 2009). A 10-year longitudinal study of Taiwanese elderly aged 60 or above did not find a significant effect of social involvement on mortality when health status at baseline was controlled (Cornman et al. 2003). Visiting or being visited by friends was not significant in reducing mortality for either men or women in a Swedish study of those aged 77 years and older. Solitary-active activities measured by gardening and engaging in hobbies were found significant for men but not for women (Lennartsson and Silverstein 2001). The effect of social activity on elderly persons aged 70 to 103 in former West Berlin was not found to be significant, but there was an interaction effect of engaging in consumptive activities (including meeting friends and other social activity) and duration of observation on survival: the longer the duration of observation, or the older the subjects, the smaller the benefit of engaging in such activities (Maier and Klumb 2005).

When examining the relationship between religious participation and mortality among Chinese elderly, Zeng et al. (2011) found that frequent or infrequent participants had lower hazard risk of death than the non-participants, and such an association was stronger among the young-old (aged 65–84) than the oldest-old (aged 85 and older). The authors concluded that "It is plausible that the health-enhancing effects of religious involvement achieved by altering health practices and lifestyles may be more pronounced among the young-old, … at very advanced ages, when life span limits are approached, social factors including religious involvement cannot exert as powerful effects on prolonging life as they can earlier in the life course" (P11).

Theoretically, the findings above are in line with the framework of the Biocultural Architecture proposed by Baltes, Baltes, and their colleagues (Baltes 1996; Baltes 1997; Baltes and Carstensen 1996; Baltes and Smith 2003). They proposed a necessary distinction between the Third and Fourth Ages, which represent the distinction of the young old (age 50 to 80 or 85) versus the oldest old (age 80 or 85 and older). There are qualitative differences between these two age groups. The transition from the Third to the Fourth Age is marked by an array

of significantly negative changes: accelerating loss in vision, hearing, strength, and functional capacity (Peeters et al. 2013), loss of resilience to negative changes, and breakdown in psychological adaptivity. Multi-dysfunctionality and multimorbidity are almost five times higher for the oldest old than for the young old. Not only do biologically-based physical functions deteriorate with age, but also the efficacy of culture-based resources and practice that compensate biological decline at very old ages do as well. The idea of changing goals and means throughout the life course was further elaborated in Baltes' theory of selective optimization with compensation, where limiting one's involvement territory is viewed as an active compensatory strategy. There is empirical evidence supporting this theory. Some studies found that the very old tended to limit social contacts to very intimate and close ties. There is a dramatic reduction in contacts with more distant social partners (Carstensen 1991; Carstensen 1992; Lang and Carstensen 1994). Johnson and Barer (1997) the elderly aged 85 or above in their sample in San Francisco were increasingly constrained by physical disability. To cope with it, they withdrew selectively from social relationships, simplifying and narrowing the boundaries of their social world. Meanwhile, they attached significant meaning to mundane, commonplace activities, such as preparing meals and listening to the radio. They did not view retreating from social relations as a negative response to their old ages. The authors concluded that withdrawal from social activities appears to be beneficial to survival at very old ages.

With regard to gender difference, some longitudinal studies of the elderly in Taiwan reported the number of social activities or being part of a religious group lowered probability of death for women but not for men (Beckett et al. 2002; Hsu 2007).

One limitation of this study is that the measure of customary physical activities under study is limited because there are no measures of volume, intensity, duration, or energy expenditure, which have been assessed in many studies (Lee and Skerrett 2001; Samitz et al. 2011). The measure of social activities suffers from the same shortcoming. Many activities are left out, such as visiting relatives, neighbors, or friends. Some research showed that social context – whether an activity takes place in the presence of others – may be more important than the activity itself (Maier and Klumb 2005). Due to data constraints, such a distinction could not be examined in the current study.

These limitations notwithstanding, this study raises a timely issue regarding promoting physical and social activity among the elderly, especially the oldest-old, which is a fast growing segment of the world population in both developed and developing countries. Since personal characteristics of the elderly vary dramatically worldwide in terms of health status, possession of socioeconomic resources, lifestyle, and daily practices, as well as social and cultural environment, variation with regard to interaction of age with engaging in physical and social activity does not seem unreasonable. Aging should be viewed as a continuous lifetime process, which constantly evolves based on the changing self and contextual resources of the elderly. The role of engaging in activities in maintaining the elderly's well-being may also change over time. There may not be a one-size-fits-all path to successful aging. Successful aging involves constant adaption. Whether a universal message, "The more involved, the better," should be sent to the entire elderly population regardless of their age or other situational factors is worth further exploration.

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Compliance with Ethical Standards

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